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THE VIRGINIA JOURNAL OF SCIENCE

VOL. 6, NEW SERIES JANUARY, 1955 NO. 1

Edgar Calvin Leroy Miller, M.D.
1867-1954

Dr. Edgar Calvin Leroy Miller, one of the founders of the Virginia Academy of Science in 1923 and *The Virginia Journal of Science* in 1940, died at the home of his younger daughter, Mrs. Gwendolyn L. Bowman, in San Diego, California, on July 21, 1954, at the age of 86. For twenty-six years, he contributed his time as secretary-treasurer of the Academy to build up this organization to its present respected reputation in Virginia and throughout the country. No scientist in the Old Dominion has ever done more for organized science on a state level than Doctor Miller. Because of this contribution, he was considered to be the dean of the Academy Conference of the American Association for the Advancement of Science, made up now of 42 academies of science. His counsel was constantly being sought by other academies to try to find out why "his academy" was so successful.

Born in Pelham, Massachusetts, in 1867, Doctor Miller was graduated from the Nebraska State Normal School in 1887. He then spent several years studying theology at Oberlin College and planned with his future wife, Lillian Belle Carpenter, careers as medical missionaries. They married in 1890 and both entered the medical school of the University of Michigan. He was awarded his M.D. degree in 1894 and then was an instructor for one year. His wife's degree was delayed one year by the birth of a son. In 1895, both Doctors Miller left for Bilaspur, India, where they served as medical missionaries for five years. Returning to this country in 1900, he joined the research staff of Parke, Davis and Company and helped to develop this organization's manufacture of biological preparations. He was sent to Europe in 1906-1907 and visited most of the scientists doing investigative work in this field. His development of diphtheria antitoxin manufacture for his company and his papers in medical periodicals of that time about the manufacture of "biologicals" won for him an international reputation when he was 40.

His "classes" at Parke, Davis and Company on new techniques having to do with the preparation of bacterial vaccines attracted physicians and laboratory men from this country and abroad. Doctor Miller liked to teach, and he was a "natural" in this field, so when an offer came to him from the University College of Medicine (a few years later consolidated with the Medical College of Virginia) in 1911 to become professor of bacteriology he gladly accepted it, even though his decision involved a substantial financial sacrifice. Successful in the medical missionary field,

outstandingly so in the commercial world, Doctor Miller began his climb to remarkable successes in the fields of medical education and organizational procedures. First of all, he established the department of biochemistry at the Medical College of Virginia in 1913 and also became custodian of what was then called the "college library" in the Virginia Hospital which was then a nurses' home. He was dean of the Medical College of Virginia School of Medicine for one year, 1920, but soon "recovered from that" as he often remarked with a twinkle in his eyes. More to his liking was a nonprofitable connection with the American Illustrated Medical Dictionary which he made in 1922 with the publishers, W. B. Saunders and Company. He enjoyed this editorial work for many years.

Then came 1923 and the organization of the Virginia Academy of Science. Dr. Miller was elected secretary-treasurer at the organizational meeting of the Academy at the College of William and Mary on April 26, 1923 and continued in this office until May, 1949, when he requested that his resignation be accepted. He agreed to serve as secretary emeritus and acted in this capacity until his death. There was none of Doctor Miller's innumerable activities which he loved more than his work for the Academy. He was overjoyed when the annual E. C. L. Miller Award for an outstanding science club of the State was initiated, not because his name was attached to it but because he had always been intensely interested in encouraging high school students with apparent aptitudes for scientific careers. When his many friends of the Academy and others cooperated to present him with his likeness in oil in 1948, he wept and kept still. Said Dr. Ivey F. Lewis in his presentation talk: "I think it may fairly be said of Doctor Miller as of Sir Christopher Wren, the famous architect who rebuilt London after the Great Fire of the 17th Century and whose influence extended to Virginia, 'If you would see his monument, look around you'."

Although officially professor of bacteriology, Doctor Miller and his able associate, Professor Robert F. McCrackan, and two assistants taught all the biochemistry at the Medical College of Virginia from 1913 to 1927. In 1929, he relinquished the chair of bacteriology and in 1930 was appointed full-time director of the library. With more time for library planning, he started up the hill again at 63 in what amounted to his fifth major undertaking. Starting with a small reading room and a few stacks, on the first floor of McGuire Hall, containing comparatively few books and periodicals, Doctor Miller, with the encouragement of the administration and the assistance of Florence McRae, Margaret McCluer, and Virginia Staub Young, built up one of the leading libraries in the South specializing in literature pertaining to the health fields. Doctor Miller was never a joiner of social clubs but in the early days of the Medical College of Virginia library he was probably the world's greatest joiner of scientific organizations in this country and abroad. He contended that it was much cheaper obtaining scientific journals this way than it was by subscriptions! He also helped to establish the library of the American Tobacco Company Research Laboratory. Almost until his death, he translated articles from several different languages for this library. Doctor Miller

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retired in 1947. When he passed away, he was Secretary Emeritus of the Virginia Academy of Science and Librarian Emeritus of the Medical College of Virginia. President William T. Sanger said upon learning of his death: "Doctor Miller's contribution to the Medical College of Virginia both as a professor and librarian was so great it could not be evaluated."

Besides a highly successful life, he enjoyed an interesting one. He always said he was introduced to science by his professor of biology at Nebraska State Normal School who gave him a project during the summer of 1884 of classifying all the snakes in the neighborhood with the request that he capture a specimen of each variety! Once, in India, Doctor Miller suffered from a toothache. He was miles from a dentist so he cleaned out and filled one of his back upper molars with an amalgam made from a coin of the realm, using mirrors to do the job. With his keen and subtle sense of humor, he often remarked that this was the only tooth he ever lost! When it was rumored during World War I that the Germans were adding powdered glass to certain American food supplies, Doctors Miller and Charles C. Haskell fed glass to dogs and swallowed some themselves. They came up with the conclusion, which was widely publicized at the time, that powdered glass that could be taken in food produced no noticeable symptoms in either in dogs or humans. (Subsequently Doctor Miller turned the tide in several lawsuits in the country involving suits for damages by individuals who claimed to have swallowed glass in soft drinks, cheese, frankfurters, ice cream, and other products.) He enjoyed corresponding with scores of individuals whom he had never seen about everything under the sun —— astronomy, psychology, segregation and even the servicing of trains and often wrote the authors of published articles with which he agreed or disagreed. After the age of 80, he "discovered" oceanography and read all he could find on the subject.

He enjoyed a happy life because he was never too busy to help someone else in trouble —— whether it was weather-stripping a house or talking a person out of despondency. In 1918, he responded to the urgent need for trained workers and offered his services to the Federal Food Administration to help with nutritional problems in Richmond and also became a member of the Volunteer Medical Corps authorized by the Council of National Defense. He was director of the emergency hospital set-up in the John Marshall High School, Richmond, Virginia, in October 1918, to care for patients at the height of the influenza epidemic.

Doctor Miller's publications in scientific periodicals had to do with a wide variety of subjects. Miss Margaret McCluer, the present librarian of the Medical College of Virginia and staunch admirer of her former director, has recently compiled a list of them which she can't be sure is complete. The subjects range from "On the Keeping of Antidiphtheritic Serum" in 1905 to "The Virginia Academy of Science Research Endowment" in 1943. Not until after his death did his immediate family know the extent of his publications!

The activities of Doctor Miller were so diversified that he never had time to be bored and he was rarely upset. When he did become upset, one could be almost sure that it had to do with someone's stupidity or deliberate injustice. He never could tolerate either. His favorite words were "vision" and "change" and with them he lived. There are all kinds of ways of walking with God——certainly this truly great scientist and selfless gentleman, whose life was given devotedly to the service of his fellowman, walked with Him in his way.

NOW, THEREFORE, BE IT RESOLVED

(1) THAT the Virginia Academy of Science will forever honor Dr. E. C. L. Miller for his devoted service as its secretary-treasurer for twenty-six years, 1923 to 1949, and

(2) THAT the Virginia Academy of Science will always be grateful to him for assisting in the establishment of The Virginia Journal of Science in 1940, and

(3) THAT the Virginia Academy of Science recognizes his outstanding accomplishment in being lately responsible for the organization of the Virginia Junior Academy of Science in 1940, and

(4) THAT the Virginia Academy of Science honors him for his unique contribution to the scientific welfare of the Old Dominion and the Nation, and

(5) THAT the foregoing resumé of Dr. Miller's career and this resolution be made a part of the permanent records of the Virginia Academy of Science and published in the January, 1955, issue of *The Virginia Journal of Science*, and

(6) THAT copies of the issue of the Journal containing the foregoing resumé of Dr. Miller's career and this resolution be obtained from *The Virginia Journal of Science* and sent to Dr. Miller's four children,

Mrs. Gwendolyn L. Bowman, 4789 Dwight Street, San Diego, Calif.;

Mr. Leland H. Miller, Box 85, Atascadero, Calif.;

Mr. Louis Miller, 208 Iini Way, Aiea, Oahu, Hawaii;

Mrs. Geraldine M. Duncan, 2915 Seminary Ave., Richmond, Va.

Respectfully submitted,

(Signed) Sidney S. Negus

NOTE: This resolution was passed unanimously by a rising vote at a meeting of the Council of the Virginia Academy of Science in Lexington, Virginia, October 31, 1954.

(Signed) Irving G. Foster, President

Sinews of Science

C. E. SUNDERLIN

Deputy Director, National Science Foundation

PROGRESS IN SCIENCE

The Mountain Lake Biological Station was established just 25 years ago. It is of special interest, therefore, to recall some of the achievements in science since 1929, a year when uncertainty and depression began to have their temporary effects on American life. An outstanding event that we witnessed during this period was the destruction of the nuclei of atoms. This feat has since been surpassed by a reversal of the process in that most terrible of all weapons, the hydrogen bomb, in which the nuclei of atoms are fused together. We have also witnessed astonishing developments in the plastics and synthetic-fiber industries; in the conquest of many types of illness and disease with the discovery of sulfa drugs and the various antibiotics, the synthesis of vitamins, and the discovery of new vaccines. The sound barrier has been broken and the jet age is upon us. Very recently there has been the announcement by Professor Marcel Schein of the University of Chicago that he has found evidence for the existence of contraterrene matter in the upper atmosphere. This discovery of the existence of particles of matter with negatively charged nuclei and energies of a million billion electron volts is perhaps one of the most important of the discoveries made in these 25 years of progress in science.

In view of the remarkable progress in science—progress that every year seems to be accelerating—it may be appropriate to pause to examine those factors that are responsible for a strong and virile science. We might think about them in the light of the dictionary definition of the word "sinew", a word which elicits connotations of strength and elasticity and durability. The word "sinew" means a tendon, or less often a nerve, or a muscle. It also means "that which supplies strength or power". What then are the factors which supply strength or power to science, and especially to science in the United States? And conversely what are the weaknesses—the degenerative diseases of muscle and tissue—that threaten our science of today?

The sources of strength may be summarized as follows:

(1) The *individual* who has the capacity for becoming a productive scientist.

(2) *Training*, without which this potential could never be realized.

(3) *Opportunity* for research, so that the trained scientist can make maximum use of his abilities.

Editor's Note: We are pleased that Mr. C. E. Sunderlin has permitted us to publish this article which is based upon remarks made at the Twenty-fifth Anniversary of the Mountain Lake Biological Station, University of Virginia, July 17, 1954.

(4) *Communication* among scientists, so that ideas can be generated in full knowledge of what has gone before and of the work in progress.

Our failure to realize the full potential of these sources of strength is a principal cause of weakness, which, if unremedied, may permit a wasting away of the tough fiber of the tendon or "sinew" of science. I should like to discuss each of these sources of strength briefly and to indicate how the Federal Government is helping to build muscle tissue, and to strengthen the tendons of science.

THE INDIVIDUAL SCIENTIST

Science is peculiarly the creation of scientists, in some instances existing only in their heads. Scientists, as human beings, and also as scholars, therefore, come in for extraordinary scrutiny. What are the qualities which the individual scientist should or must have? What are the innate characteristics which must be possessed by the individual before training and opportunity can assist in his development as a creative scientist? I know of no other class of scholars—historians, economists, sociologists—whose personal characteristics have been so minutely scrutinized and analyzed. Perhaps this is because, as G. K. Chesterton once aptly put it — and this many years before the atomic bomb—:

> Men find it extremely difficult to believe that a man who is obviously uprooting mountains and dividing seas, tearing down temples and stretching out hands to the stars, is really a quiet old gentleman who only asks to be allowed to indulge his harmless old hobby and follow his harmless old nose. When a man splits a grain of sand and the universe is turned upside down in consequence, it is difficult to realize that to the man who did it, the splitting of the grain is the great affair, and the capsizing of the cosmos quite a small one. It is hard to enter into the feelings of a man who regards a new heaven and a new earth in the light of a by-product. But undoubtedly it was to this almost eerie innocence of the intellect that the great men of the great scientific period, which now appears to be closing, owed their enormous power and triumph. If they had brought the heavens down like a house of cards, their pleas was not even that they had done it on principle; their quite unanswerable plea was that they had done it by accident. Whenever there was in them the least touch of pride in what they had done, there was a good ground for attacking them; but so long as they were wholly humble, they were wholly victorious.

Small wonder, then, that the rest of mankind wants to know, with a great deal of interest and not a little suspicion, what the "quiet old gentleman" is really like.

Several years ago, a psychologist, Dr. Anne Roe, under a grant from the United States Public Health Service, undertook a serious study to determine the factors that contribute to scientific greatness. She based

her study upon an analysis of some 60 pre-eminent scientists——about 20 in biology, 20 in the physical sciences, and 20 in the social sciences. In additon to the scientific papers in which she has published her findings, Dr. Roe has also published a popular book, *The Making of a Scientist*. Dr. Roe's book is enjoyable reading, particularly for scientists, because, of course, it is always interesting to see ourselves dissected and analyzed in so painstaking a fashion.

It is significant that after her extensive study, Dr. Roe (1953) concludes:

> One thing seems clear. Scientists are people, not rational automatons. They differ from other people in terms of what they do, in the things that give them satisfaction, more than in terms of completely special capacities. There is nothing you can say about them as persons that you cannot also say about some people who are not scientists. And there is almost nothing you can say about a man in some particular field of science that you can not also say about someone in another field of science.

Dr. Roe does find, however, that scientists tend to have many things in common; so that in studying their lives, one finds patterns in their backgrounds, in their intellectual abilities, in their personality structure, and so on. Such traits as native intelligence, imagination, and ingenuity are essential. In addition, however, the individual must have the attributes of curiosity and skepticism.

Curiosity is a quality different from imagination. It is a habit of mind, a driving force that permits the exercise of intelligence and imagination in the solution of a particular problem. Curiosity is a strongly motivating factor——it is undoubtedly responsible for the selection of a scientific career by many able and intelligent students, who wish to know and understand the causes of the natural phenomena in the world around us. They wish to understand and explain the origin of the species, genetic variability, the attraction of physical bodies, the nature of the atom, the motions of the stars, the structure of the universe.

To curiosity must be added skepticism, the attitude of mind that takes nothing for granted, which demands proof of statements, beliefs, hypotheses, and laws. The true scientist is a skeptic, a doubting Thomas in the best sense of that phrase. He is, also, more often than not, a nonconformist in his thinking. As *Fortune* (Bello, 1954) pointed out in a recent article:

> The scientist, particularly the most gifted, is, by almost any definition, a maverick. His endowments, drives, interests, political opinions, and even religious beliefs are not, in most cases, those of the majority of society. In the total population of the U. S. the scientist is at most one in 3,000, and if the term scientist is reserved for only the independent investigator, on whom virtually all scientific progress depends, the ratio is more like one in 30,000.

As more and more emphasis is placed on conformity, there is less and less room for the brilliant individual of unconventional thinking. This is a country to which the maverick has contributed a great deal, and it would be a great pity if we were to deprive ourselves of his unpredictable gifts.

TRAINING OF SCIENTISTS

The training of a scientist never ceases—if he is to remain a scientist. There are, however, certain recognizable periods during which the process of training is rigorous and intensive. In the university and in the graduate school this is particularly true, and to a lesser degree in high school. There are thus three times of decision when a critical choice is made, determining in each case a series of events in the career of the potential scientist.

The first of these is the most uncertain of the three. It comes at a time when the interest and curiosity of the student—often still in grade school—have been stimulated to such an extent that he is motivated toward scientific activites. Such a stimulus might come from an inspirational teacher, a science TV show such as the "Johns Hopkins Science Review," or "Watch Mr. Wizard," elementary descriptive books on natural phenomena such as those on plants and flowers and trees, written by experts in the Fish and Wildlife Service of the Department of the Interior. Whatever the reasons, at some indeterminate time the student makes this first decision that he will follow scientific pursuits. The decision has been based on a combination of knowledge, thought, and emotion, *and* an interest that is easily lost if the motivation is not kept alive. It is by no means a final decision. The way may be hard and enthusiasms die.

The second time of decision occurrs at the transition point between high school and college. At this time the decision is harder for some and easier for others. In some cases there may be merging of first and second decisions. Many who would like to go on to college do not do so, however, for a variety of reasons. At the present time only one student in three who graduates from high school enters college. More important, 47 per cent of those high school students of high ability do not go on to college or university. The loss that occurs here is an undetermined loss that is a potential source of weakness, not only to sinews of science, but to all other fields as well.

The third time of decision occurs in the transition from undergraduate to graduate study. Science has become increasingly complex and specialized, and there is need for longer periods of training than in the days of Newton, Galvani and Galileo. In their times the body of cumulative knowledge was much smaller than it is now. Today, however, the young man or woman who is seriously contemplating a career in science knows that the B.S. degree is probably not going to be sufficient to advance him very far in research. A bronze plaque in the halls of Monmouth College reminded students of the oft-repeated words of their chemistry professor, William S. Haldeman: "The Bachelor's degree is not enough." The young scientist is beginning to acquire momentum at the time of his third decision and this momentum must be conserved.

The crucial nature of this transition point was kept in mind when the Foundation decided to emphasize first-year graduate fellowships in its fellowship program. On March 15 of this year announcement was made of the award of 220 first-year graduate fellowships, as well as 240 intermediate and 197 terminal-year fellowships in the sciences. There were also 79 postdoctoral fellowships.

In addition to support of training through fellowship programs, the training of students is aided through the grants and contracts for research at universities and colleges by such agencies as the Office of Naval Research, Atomic Energy Commission, National Institutes of Health, Department of Agriculture, and, of course, the National Science Foundation.

Before leaving the subject of assistance for graduate training, however, there is one note of caution that I believe should be sounded. Dr. Roe has pointed out that if opportunities for graduate training are *too* numerous and *too* easily available, some of the motivation to acquire such training may easily be destroyed. She reminds us that in harder times a sort of natural selection took place of those individuals who were strongly enough motivated to obtain their graduate training despite the difficulties involved. I believe that those of us who obtained our own training in the lean years of the depression would find it easy to agree with this premise.

Turning now to other elements that enter into the training of scientists, we should all probably agree that the teacher is a vital fiber, if not the most vital, in the sinews of training. His fund of knowledge and his capacity for inspiration permeate and infuse the whole of the educational process. The work of Professors Goodrich and Knapp of Wesleyan University has placed in bold relief the role of the teacher of science in our liberal arts colleges. Their studies show that certain of the small liberal arts colleges have distinguished records in graduating individuals who later obtain doctoral degrees in science. The proportion of their graduates who go on to careers in science is far greater than the average for the large universities. The fifty institutions that lead in the production of scientists include, among others, Reed College, Oberlin, Hope, Charleston (South Carolina), West Virginia, Wesleyan, Haverford, Montana State, and other comparatively small schools. Their success is attributed in large measure to one or two members of the science faculty of each institution. These teachers have the capacity for imparting knowledge in such a manner that the students become more than receptors; they develop the curiosity and skepticism so vital to a continued career in science.

The success of certain of these smaller institutions in inspiring careers in science points up a problem that is seldom discussed. This is the failure of the universities to stimulate a larger proportion of their undergraduates in science to continue as graduate students. This may be the result of preoccupation with their own research on the part of faculty members; the lack of a properly intimate environment for catalyzing interest in research as a profession; the failure to attract fine teachers because of undue emphasis upon the publication of research papers. Here again is a possible source of weakness for science, in spite of the outstanding

record of the larger universities in providing the graduate school environment so essential to advanced training in science.

The ideal situation, of course, is one in which both teacher and school are equally strong and effective. In the absence of the ideal, however, there can be little doubt that it is the teacher who is the crucial element in the development of young scientists.

OPPORTUNITIES FOR RESEARCH

Opportunities for reasoned thought and investigation of problems in science are primarily limited by the imagination and ingenuity of the individual scientist. At the same time, however, the increasing complexity and specialization of science have created requirements for physical facilities and equipment undreamed of 25 years ago. We were not concerned at that time with high-speed particle accelerators, cryogenics, high-temperature and high-pressure research, upper-atmosphere research, and so on. Such studies as these have created logistic problems of substantial size. One wonders: Could the universites and colleges have financed research in these fields from their own resources?

Research in these fields is expensive in time, money, and materials. The universities have had to face an increasingly expensive economic world with a generally static income of lower purchasing power. The dilemma was before them in 1939 but was postponed temporarily by World War II and the concentration of scientific effort on war problems through the Office of Scientific Research and Development. In 1945 and subsequent years this dilemma was still present but was ameliorated by the actions of ONR, NIH and AEC in providing support for research in academic institutions.

Thus, pending the establishment of the National Science Foundation, other agencies of the government developed programs of research support in universities, research institutes and medical schools, net only to solve problems of direct concern to them, but to maintain a healthy and vigorous scientific effort in the country. This arrangement was not, and is not, altogether altruistic, nor is it a marriage of convenience. There was general recognition of two important facts: (1) the urgent necessity of maintaining our leadership in scientific research, and (2) the importance of increasing our capacity for performing basic research. The two are intimately related to national strength and national security.

Opportunities for research exist abundantly in the laboratories of the universities, industry, and government. The 20th-Century worship of the machine can be a source of weakness, however, if not tempered with the recollection that many great discoveries have come from relatively simple experiments and keen observation. Archimedes and his bathtub, Franklin and his kite, Bragg and his soap bubbles, Langmuir and his soap films, Powell and his nuclear emulsion plates are only a few of the examples one could cite.

The combination of research with training in the universities is the backbone of ultimate scientific progress in this country. To remain strong, financial freedom must be combined with intellectual freedom. Another

possible source of weakness is a dependence upon government for too large a proportion of financial support, and an emphasis upon applied research which will, in the words of Vannevar Bush (1945), "invariably drive(s) out pure . . . unless deliberate policies are set up to guard against this".

The danger is real. In 1952 only one dollar out of each five spent by the Federal Government in support of scientific activities at universities was for basic research. The other four dollars went for applied research and development. The muscle of research capacity in the universities must not be stretched too far, nor in the wrong direction.

COMMUNICATION

Science without communication is like the links of a chain scattered loose upon the ground. There is no chain; the only strength is that of individual links.

Science is dynamic and builds constantly upon the past. "The past is prologue" in a very real sense, as witnessed by the hundreds of thousands of scientific papers that accumulate in journals and are abstracted, documented, referenced, collated, and translated. These are the stepping stones to the future, as well as a medium for communication of research results.

There are certain boundaries and barriers to communication, however —both natural and artificial. The sheer bulk of scientific information, which now requires the development of machine methods for its efficient use, is one of the most serious problems in communication. Another is the lack of a single international language for science. Important research is being done behind the Iron Curtain, for example, but we know all too little about it because of our lack of proficiency in the Slavic languages.

A barrier of constantly growing dimensions is the mounting volume of scientific and technical information subject to security restrictions. Is it possible that in our anxiety to safeguard legitimate secrets of military import, we have somehow thoroughly confused secrecy with security, until the thing that we seek to nurture is in some danger of being smothered in the process? Recently Mr. Lloyd V. Berkner, president of Associated Universities, Inc., which, as you know, administers the Brookhaven National Laboratory, called for a sober reappraisal of the effects of technological secrecy upon the progress of science. Mr. Berkner (1954) said:

> Since more and more of our scientific activity is coming within the purview of secrecy, the need for appraisal of the effects of secrecy on our scientific stature and progress, and therefore on our national security, becomes of increasing importance. It seems highly probable that a little technological secrecy, like a little poison, may be a good thing, but too much can destroy us . . . As scientists, can we not demonstrate to the public how the benefits of science will quickly be extinguished by widespread technological secrecy? Can we not demonstrate that in suppressing

> seemingly isolated scientific bits of information of direct military value, we at the same time prevent the germination of scientific ideas of much greater scientific, social, and military significance? Can we not show that such really great concepts, injected into our industrial complex, can provide far greater security through technological supremacy than we could ever hope to achieve through the secrecy of technological information?

Still other obstacles to the free flow of scientific information are the immigration and visa laws, which have the essential purpose of promoting our national welfare and security, but have simultaneously made it difficult or impossible for many scientists to communicate directly with one another.

Since communication is the life blood of science, the Foundation has supported research in documentation, in the translation of Russian scientific papers, and has advocated changes in the immigration laws that will safeguard our security while still permitting personal communication between scientists. We have also supported a program of assistance to American scientists traveling abroad for the purpose of attending international scientific meetings.

CONCLUSION

In this brief enumeration of the principal sources of strength in science—that is, the individual scientist, his training and opportunities for research, and communication among scientists, I have tried to single out some of the possible weaknesses to which science is vulnerable in each of these categories. I have mentioned our failure to motivate students of high ability toward careers in science; the loss of potential scientists at various stages of career decision; the emphasis upon machines to the possible exclusion of simple experiments and observation; the danger to our universities in the imbalance between applied and basic research; and the overload on our communication system in science.

I should like to close with the reminder that the greatest weakness of all may be the possible loss of intellectual freedom as a result of the uncertainty and fear arising from our current activities with respect to security and loyalty. These problems confront the citizens of this country because of the temper of the times and the chaos in the world today. Nothing could be worse, however, than the isolation of scientists as a group and their subjection to special treatment simply because their ability, training and experience have made them increasingly important in national affairs. I should like to quote Dr. Bush again, this time from the article that appeared in the New York Times of June 13, 1954. Dr. Bush (1954) said:

> Scientists need to be used not as lackeys or underlings but as partners in a great endeavor to preserve our freedoms. They need to be welcomed, so that they will respond in spite of the lure of peaceful pursuits, because they are inspired and heartened

> as they join with their fellow men to preserve their way of life. They need, as do we all, words, and, far more important, acts and deeds to renew hope in troubled and loyal minds. They need to see, set up on a pedestal, fortified by the strongest bulwark in Executive acts, those principles which we would abandon at our peril.

This is another way of saying what Thomas Jefferson said over 150 years ago:

> I have sworn upon the altar of God eternal hostility against every form of tyranny over the mind of man.

As the National Science Foundation grows in age and experience, so, too, we hope, will grow its contributions to our national strength in science. But no single agency or group of agencies, however wise and experienced, can meet the need in and of themselves. It must be the whole scientific community, and this means each individual member of the scientific community, who must bring about a better understanding of the nature of science and (if you will) of the peculiar nature of scientists. For it is only when people generally have acquired an understanding and application of those elements that make science strong, as well as those things that may weaken it, that we can feel that science in the United States is truly secure in an ultimate sense.

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Physiological Aspects of Testing Contact Chemoreception. A Symposium [1]

INTRODUCTION

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The processes of detecting chemical compounds by an animal, either at a distance or in contact with a special tissue of the animal's exterior, are ancient abilities. Simple animals without backbones relied upon their chemical senses for survival and propagation of the species long before the evolution of eyes and ears. Since man has gained a dynamic ascendency over the animals, he has come to rely largely upon vision and hearing and his senses of smell and taste have been assigned a minor biological value by the older students.

As much of the enjoyment of life is derived from delectable foods and beverages, scents and perfumes, there is a very considerable production of commodities which impinge upon our chemical senses. Consequently, during the mid-twentieth century there has been a renaissance of scientific investigation as well as applied research in this department of sensory physiology. The motivation is as much a demand by consumers for better product-performance and more varied applications, as for pure scientific interest. In fact, it is not at all fantastic to prophesy that there will develop, during the next generation, an interest among people to sharpen their individual olfactory and gustatory senses by learning more about how to use them. Modern man has created many new flavors and odors, some of them serving the practical end of self-preservation, while others provide enjoyment.

The truth is, though, that we have only a limited understanding of the fundamental processes or mechanisms for reception of a stimulus by the chemoreceptors. This applies to the taste buds and their analogous organs in the simpler animals with which we are concerned in this symposium. Before the applied scientists and technologists of industry can create new savory substances, a precise knowledge of the activation of the taste buds is needed.

Whether this mechanism is physical, chemical, physicochemical, or biochemical in nature is a subject of much interest today. Some scientists hold that part of the answer has been elucidated, which is to say that the nature of the adequate stimulus has been determined to be ions of hydrogen and sodium. That the adequate stimulus, the least amount of

[1] This article together with the four with follow immediately were read at a Symposium of the Graduate Summer Session in Statistics at the Virginia Polytechnic Institute, June 25, 1954. James W. Johnston, Jr. presided at the Symposium.

* Paper received August 31, 1954.

energy of a particular form necessary to discharge an electrical impulse by a taste-receptor, is not a simple, chemical entity is clear. On the other hand, the mechanism of "bitter" and "sweet" sensations is not clear. We are not certain, for instance, why two such chemically different compounds as cane sugar and saccharin give us a "sweet" sensation. Thus, a significant part of the elucidation of the mechanism of excitation lies ahead.

The theory of taste has a second aspect in the nature of the receptor cell, whose function it is to lower the threshold of the nerve fiber to some one form of energy. In the black blowfly (green bottle fly) a curved, blunt-tipped bristle is the contact chemo-receptor of one of the jointed mouth parts (labellum) and the front pair of legs (Grabowski and Dethier, 1954). The exterior surface is dry in contrast to the taste buds of mammals and man, which are exposed to saliva. In place of a stiff external bristle, our receptors are found in the taste buds on the tongue.

A dozen or more elongated receptor cells, some of which have minute hair-like processes at the outer end, occur in a taste bud. The "hairs" project through a pore into the mouth cavity. Direct stimulation may take place on them and the impulse pass through the receptor cell to a nerve fiber and thence to the brain. It has been estimated that there are about nine thousand of these microscopic buds in man (Moncrieff, 1951).

Unfortunately for a broad or comprehensive theory of gustation, the chemical nature of the mammalian receptor is not known. In all probability it is different from the insect receptor. Whether this difference has fundamental significance is a matter for conjecture. That is why good comparative experiments that will lend themselves to powerful statistical analyses are needed. A clear proof of a basic similarity or dissimilarity would advance importantly our understanding of contact chemoreception. The present status of the field will be presented in the essays which are to follow by discussions of the sapid molecules, the invertebrate animals, the mammals, and finally by an interesting account of how humans react when stimulated by certain foods.

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Physiological Aspects of Testing Contact Chemoreception. A Symposium

MOLECULAR STRUCTURE AND TASTE STIMULATION[1]

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What is the chemical cause of taste? There are only four distinct kinds of taste —— sweet, sour, salty, and bitter —— so only a few variables seem involved, yet the question still ranks among the unsolved problems of science. The puzzle is made more mysterious by the recent observations that certain chemicals will prove tasteless to one fraction of a sampling audience, bitter to another fraction, and sweet to a third fraction —— with surprisingly constant statistics! Only a few such substances are known (e.g., phenyl thiourea), but these singular discoveries prove that the taste response can be complicated by subjective differences of a hereditary nature.

Asymmetric molecules provide another important clue: a number of naturally occurring amino acids have a sweet taste, and can be described structurally as "left-handed" molecular forms; the corresponding "right-handed" amino acids, though mirror images and identical in every other respect, are tasteless! Thus the tasting mechanism also must involve some sort of hand-and-glove (or lock-and-key) matching contact between the tasting molecules and the tasted ones.

The most plausible theories of taste presume that the sensitive taste-bud surfaces are protein mosaics with repeating positive and negative electric charge patterns. These electric dipoles, or "taste couples," as R. B. Warfield[2] recently described them, are unbalanced by contact with a matching electric dipole in the tasting molecule, and this interaction "triggers" the nerve impulse.

Since the taste signal must be due to actual contact with these electrically active parts of the stimulating molecules, the puzzle reduces to a search for correlations with dipolar atomic groups. Eventual elucidation of the taste responses should be aided by the use of systematic structure descriptions, such as those given in the tables of this report.

R. W. Moncrieff[3] summarized "Taste and Constitution" with eight different theories of taste, and fifty-eight general relations between taste and chemical constitution. The complexity of the problem appears with the great variety of sweet and bitter substances, but even the relatively simple salty taste shows some significant variation with dilution.

Salty taste can be associated with simple ionic compounds of low molecular weight, and the characteristic taste of these metallic *salts* may be

[1] See footnote on page 11
[2] R. B. Warfield, Abstracts of Papers, 125th Meeting of the American Chemical Society, September, 1954, page 15A.
[3] R. W. Moncrieff, "The Chemical Senses," Wiley, New York, 1946, pages 273-278.
[4] Paper received September 30, 1954.

due to their high degree of hydration: similar ionic compounds of heavier molecular weight generally taste bitter. *Sour* taste is due to the hydrogen ion of simple acid structures.

Clues to the ultimate solution of the total tasting mechanism may be found in dualistic tables of chemical structures that compare sweet-tasting substances with nonsweet ones, among the simplest classes of chemicals. The four simplest classes of such structures are, in elementary terms, (1) the open-chain or aliphatic compounds of carbon, hydrogen, and oxygen; (2) the aliphatic nitrogen derivatives; (3) the aliphatic sulfur derivatives; and (4) the aliphatic halogen derivatives. The several hundred sweet and nonsweet aliphatic compounds mentioned in Moncrieff's treatise have been described with systematic structural symbols and listed in the illustrated tables according to these four elementary classes. The nitrogen derivatives form such a large group that they have been subdivided into two tables.

Oxygen derivatives of the open-chain hydrocarbons contain two characteristic dipole groups in addition to the lone "etheric" oxygen segments: the hydroxyl or —— OH group (here denoted by the letter Q), and the carbonyl or —— CO. —— connective (here denoted by the letter V). The less active hydrocarbon chains are identified distinctively by arabic numerals which show the *number of carbon atoms* in the represented alkyl group. Ternary carbon atoms are denoted by the leter Y (suggestive of the bond pattern), and quaternary carbon atoms by the letter X; prime marks on X or Y denote methyl groups (following a contraction suggested by W. Gruber). A fully detailed account of the general notation is given elsewhere.[4]

Table I shows that the sweet-tasting oxy-derivatives generally contain hydroxyl groups (Q) while the sour-tasting derivatives contain carboxylic acid groups (QV). However, this table includes a sufficient number of exceptions, even with this small number of structural variables, to hint at the subtlety of the tasting mechanism.

Nitrogenous structure descriptions introduce four new atomic group symbols in addition to the letter N for lone nitrogen atoms: W for the two oxygen atoms in the nitro or NO_2 group, K for the quaternary and cationic nitrogen atom, M for the imino or mid-amino NH group, and Z for the terminal ("hydrazino") amino group, NH_2.

Table II compares the sweet and nonsweet substances that contain lone or quaternary nitrogen atoms (N or K, respectively); table III compares those that contain the hydrogenated imino or secondary amino and primary amino groups (M and Z, respectively). Here again the structural variations given abundant evidence for the subtlety of the relation between taste and constitution. For example, some nitro compounds are bitter, though most of the listed ones are sweet; the long-chain acid betaines are bitter, but betaine and homobetaine are sweet; carbylamines are bitter, but the isomeric nitriles are sweet. (In these structural generalizations, the nonspecific or generic letter A denotes any alkyl group)

[4] W. J. Wiswesser, "A Line-Formula Chemical Notation," Crowell, New York, 1954.

Table IV includes corresponding examples of the aliphatic sulfur compounds cited by Moncrieff; most of these are bitter-tasting substances. The prevailing "bitterness" of the lone sulfur atom is in striking contrast with the intense sweetness of saccharin and related structures that contain a cyclic sulfonyl or — SO_2 —· group.

Table V compares the sweet and nonsweet aliphatic halogen compounds. In this table, chlorine atoms are denoted by the letter G (which avoids the typewriting ambiguity of Cl) and bromine atoms, by the letter E.

Moncrieff's treatise contains many additional examples of benzenoid and other cyclic structures, which have been listed in similar dualistic tables of structure descriptions. These tables have not been included in this paper since they offer no striking clues in the problem of correlating structure with taste; the author will gladly furnish copies of these additional tables to those who wish to explore this challenging biochemical puzzle.

The reader who searches for structural correlations in these or similar tables might rediscover some of the fifty-eight general relations cited by Moncrieff, and he might account for the facts with fewer than eight theories, but he is forced to a minimum conclusion that there is no simple structural characteristic that causes sweetness or bitterness. The ultimate explanation must come with more subtle physical details, such as the fractional electric charge distributions among these atomic groups, or the angular relations among these charges that are possible in each surface-slithering molecule.

TABLE 1.—ALIPHATIC OXYGEN COMPOUNDS

NONSWEET SUBSTANCES		SWEET-TASTING SUBSTANCES	
Notation	*Name Identification*	*Notation*	*Name Identification*
1V1	Acetone	1OVYQYQVO1	Dimethyl tartrate
1VO6OV1	* Hexamethylene glycoldiacetate	1Y'1VO1	Methyl isovalerate
		3VO2	Ethyl butyrate
2OV4VO2	* Diethyl adipate	3VO3	Propyl butyrate
6V1	Methyl hexyl ketone	Q1X1Q1Q1Q	Pentaerythritol
8OV1Y"	Octyl isovalerate	Q1YQ1Q	Glycerol
O:1	Formaldehyde	Q1YQ, 1:O	D-Glyceraldehyde
O:2	Acetaldehyde	Q1YQ/1:O	L-Glyceraldehyde
O:2:Y'3:Y"	Citral	Q1YQYQ2:1	Hexenyl glycerin
O:2Y'3:Y"	Citronella	Q1YQYQYQYQ1:O	Aldohexoses (Glucose, mannose, etc.)
Q1:O	Formic acid (sour)		
Q2O1	Glycol methyl ether	Q1YQYQYQYQ1Q	Hexitols (Sorbitol, mannitol, etc.)
Q4	Butyl alcohol		
Q6Q	*Hexamethylene glycol	Q2	Ethyl alcohol
QV1	Acetic acid (sour)	Q2Q	Ethylene glycol
QV2VQ	Succinic acid (sour)	Q3Q	Trimethylene glycol
QV3	Butyric acid (sour)	Q4Q	Tetramethylene glycol
QVVQ	Oxalic acid (sour)	Q8	Octyl alcohol
QVY':1VQ	Citraconic a. (sour)	QY'1Q	Propylene glycol

* Bitter.

TABLE I. ALIPHATIC OXYGEN COMPOUNDS (Continued)

NONSWEET SUBSTANCES		SWEET-TASTING SUBSTANCES	
NOTATION	NAME IDENTIFICATION	NOTATION	NAME IDENTIFICATION
QVYQ1VQ	Malic acid (sour)	QY':6	2-Octen-2-ol
QVYQYQVQ	Tartaric acid (sour)	QY3.Y':2	3-Me-2-Hepten-4-ol
QY'6	*Methyl heptyl carbinol	QY5.1:1	1-Octen-3-ol
QY'VQ	Lactic acid (sour)		

TABLE 2.—ALIPHATIC NITROGEN (N, K) DERIVATIVES

BITTER SUBSTANCES		SWEET-TASTING SUBSTANCES	
Notation	*Name Identification*	*Notation*	*Name Identification*
1K*,-Q	Tetramethylammonium hydroxide	NCA	Nitriles (Cyanides)
AKA,A.A,-Q	Quaternary bases	NNNA	Azides
ANA.A	Tertiary amines	ONO2	Ethyl nitrite
ANA.VNA.A	Tetra-alkyl ureas	OV1K*	Betaine
CN1	Methyl carbylamine	OVY'K*	α-Homobetaine
CN2	Ethyl carbylamine	QN:A	Oximes (Aldo- or keto-)
ONO2:1	Allyl nitrite	QN:Y1Q1Q	Di-HO-acetone oxime
OV14K*	ω-Aminopentadecylic acid betaine	QV1ON:A	Oxim-acetic acids
0VY2.K*	Trimethyl α-aminobutyric acid betaine	WN2	Nitroethane
		WN5	Nitropentane
		WNO1Y"	Isobutyl nitrate
WN2:1	Nitroallyl	WNO4	Butyl nitrate
WNX'2.2	*tert*-Nitrohexane	WNY'NW	Dinitroethane (1, 1-)
		WNY2.NW	Dinitropropane (1.1-)

TABLE 4.—ALIPHATIC SULFUR DERIVATIVES

BITTER SUBSTANCES		SWEET-TASTING SUBSTANCES	
Notation	*Name Identification*	*Notation*	*Name Identification*
ASA	Thioethers	S:YS1.O2	Methyl xanthate
ASSA	Dialkyl disulfides	S:YSA.O2	Alkyl xanthates
SH2M1	β-Methylaminoethyl mercaptan		
SHA	Mercaptans		
SHVA	Thioamides		
S:YZMA	Thioureas		
WS2.X"SW2	Sulfonal		
WSA.OA	Alkylsulfonic esters		

* Bitter.

TABLE 3.—ALIPHATIC NH AND NH_2 DERIVATIVES

NONSWEET SUBSTANCES	
Notation	*Name Identification*
1MVM1	°*sym*-Dimethyl urea
1VMV1	°Diacetamide
Z1	°Methyl amine
Z14VO1	° Methyl ω-aminopentadecylate
Z14VQ	ω-Aminopentadecylic acid
Z16VO1	Methyl ω-aminopentadecylate
Z16VQ	ω-Aminoheptadecylic acid
Z1:O	° Formamide
Z7	°Heptyl amine
ZMVY4.VMZ	°Bu Malonic dihydrazide
ZMV2VMN:2	°Acetaldehyde succinic dihydrazide
ZMVVQ	Oxalic hydrazide
ZMVYMZVMZ	Malonic trihydrazide
ZV1	°Acetamide
ZV1Q	°Glycollic acid amide
ZV2	°Propionamide
ZV1VZ	Malonamide
ZV4VZ	Adipamide
ZVM4O2	° ∂-Ethoxybutyl urea
ZVNVZVZ	Triacetamide
ZVO2	° Urethane
ZVVZ	Oxamide
ZVZ	°Urea
ZYVQ,1V2	D-Asparagine
ZYVQ,1Y″	D-Leucine
ZYVQ,Y″	D-Valine
ZYVQ,Y′2	°D-Isoleucine
ZVYNW.CN	Nitrocyanacetamide (sour)

SWEET-TASTING SUBSTANCES	
Notation	*Name Identification*
1VMMVMM1	Diacetyl carbohydrazide
O:1M1	Methyl formamide
QV1M1	Sarcosine
QV3M1	γ-Methylaminobutyric acid
Z1VQ	Glycine
Z2VQ	B-Alanine
ZMVY′VMZ	Me Malonic dihydrazide
ZMVY2.VMZ	Et Malonic dihydrazide
ZMVY3.VMZ	Pr Malonic dihydrazide
ZMV2VMZ	Succinic dihydrazide
ZMVVM1	5-Methyl semi-oxamazide
ZMVYA.VQ	Alkyl malonic hydrazides
ZMVYQ1VMZ	Malic dihydrazide
ZMVYQYQVMZ	Tartaric dihydrazide
ZV1VMA	Alkyl malonamide
ZV3	Butyramide
ZVN1.1	*as*-Dimethyl urea
ZVN2.2	*as*-Diethyl urea
ZVVMZ	Semi-oxamazide
ZX″1VQ	β-Aminoisovaleric acid
ZX″VQ	α-Aminoisobutyric acid
ZY′VQ	Alanine (D- or L-)
ZYVQ/1VZ	L-Asparagine
ZYVQ/1Y″	L-Leucine
ZYVQ/2	L-Aminobutyric acid
ZYVQ/3	L-Norvaline
ZYVQ/4	L-Norleucine
ZYVQ/Y″	L-Valine

° Bitter.

TABLE 5.—ALIPHATIC HALOGEN DERIVATIVES

NONSWEET SUBSTANCES	
Notation	*Name Identification*
E2:1E	1,3-Dibromopropylene
G2OV3	*Chloroethyl butyrate
GY3.Y'G	*2,3-Dichlorohexane
G1G1O1YGG	**s*-Tetrachloroethyl ether
O:1XGGG	*Chloral
QV1G	Chloracetic acid (sour)
QYQXGGG	*Chloral hydrate
WN2G	1-Chloro-2-nitroethane
WNY'G	1-Chloro-1-nitroethane
Z1X'SW2.SW2/GH	Aminosulfonal MC1
ZHH,.E	*Ammonium bromide
ZHH,.G	**Ammonium chloride
ZHH,.I	*Ammonium iodide
ZV1G	Chloroacetamide
ZV1I	Iodoacetamide
ZVXGVZ2Y"	* Isoamyl Chloromalonamide
ZVXGV'ZY"	* Isopropyl Chloromalonamide

SWEET-TASTING SUBSTANCES	
Notation	*Name Identification*
E1YE:1	2,3-Dibromopropylene
G1	Methyl chloride
G1Y"	Isobutyl chloride
G2	Ethyl chloride
GA	Alkyl chlorides
GY"	Isopropyl chloride
GYGG	Chloroform
GYGXGGG	Pentachloroethane
GYGYG1G	1,1,2,3-Tetrachloropropane
GYGYGG	*s*-Tetrachlorethane
ZVXEEE	Tribromacetamide
ZVX'GVZ	Me Chloromalonamide
ZVXG2.VZ	Et Chloromalonamide
ZVXGG.VZ	Hx Chloromalonamide
ZVXGGG	Trichloroacetamide
ZVYEE	Dibromacetamide
ZVYGG	Dichloracetamide

* Bitter.
** Salty Bitter.

Physiological Aspects of Testing Contact Chemoreception. A Symposium

THE COMPARATIVE PHYSIOLOGICAL APPROACH TO THE STUDY OF CHEMORECEPTION[1]

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The comparative physiologist attempts to contribute to any field of biological investigation in at least two ways. First, by studying a physiological process in many different animals, he tries to determine what is essential to the process, and what may be a peculiarity typical of one particular experimental animal. Secondly, by selecting animals which lend themselves to particular experimental techniques, he tries to shed some light on aspects of the problem which otherwise could not be studied. It is primarily the latter type of approach which will be discussed here.

As has been indicated elsewhere in this symposium, the accessibility of invertebrate chemoreceptors and the lack of an overlying mucous layer in many forms constitute the major reasons for studying invertebrate animals when attempting to obtain fundamental knowledge of chemoreception. Another advantage of invertebrates is that relatively large homogeneous populations of experimental animals can often be obtained. Small size and short life cycles permit rearing of thousands of individual animals under almost identical conditions. This, of course, makes it easier to characterize the responses of the population in a meaningful statistical way, and hence the individual variations in thresholds or reactions, which have to be expected in all biological material, are not apt to be misleading.

It is not within the scope of this paper to attempt an exhaustive review of the contributions from comparative physiology to the understanding of chemoreception. As an example, one question of fundamental importance in this field will be treated through an analysis of pertinent experiments, giving particular attention to the statistical methods used. The question is usually stated somewhat as follows: What are the essential properties of a chemical compound that cause it to have its effect on a receptor cell? Certain generalizations, in partial answer to this question, have become widely accepted among comparative physiologists, and the evidence on which these generalizations rest may be analyzed as representative of the comparative physiologist's approach.

In theory, the chemoreceptors of a large homogeneous population of animals are exposed to known concentrations of various chemical stimuli.

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[1] See footnote on page 14.
[2] Public Health Service Research Fellow of the National Institute of Neurological Diseases and Blindness.
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An arbitrary measure of response by the population is regarded as "threshold". Comparisons of the thresholds of responses toward different chemical stimuli enables the investigator to rank the chemical stimuli in their order of relative stimulating effectiveness. Then any property of the chemicals which is present to a larger degree among highly stimulating compounds than among relatively ineffective compounds is examined as a possible clue to the essential properties of a stimulus. If, in a large series of compounds, a good correlation is found between such a property and the stimulating capacity of the compounds, the property is considered a likely prospect for being included among the essential ones, and its occurrence among a new series of chemicals is used for predicting their relative order of effectiveness. If the predictive value of the tentative new concept is found to be high, the whole process is repeated using other types of experimental animals. Only if similar results are then obtained can the new idea regarding the nature of the essential stimulating property be accepted as having any general biological significance. It will be obvious that some kind of statistical analysis must enter into this process at many points. A more specific analysis should make clear the particular statistical methods which have been found to be generally useful.

Suppose that the experimenter is impressed with the number of cases in which inorganic salts are known to stimulate chemoreceptors. It is well known that these salts differ widely in their capacity to stimulate chemoreceptors. The problem is to find out what properties of these salts determine their stimulatory power. An animal is chosen in which the salts stimulate the same small group of receptors. An apparatus is devised for administering known quantities of stimulant and permitting easy study of the reaction of the animals. (There is good evidence that the reaction of the whole animal can be used as a reliable measure of the stimulation of chemoreceptors in many invertebrate animals.) With each one of the salts to be tested, a series of doubling concentrations is prepared and used in the experiment. (The difference between concentrations tested is kept large so that differences in powers of discrimination by members of the test population will not influence results.) The population is exposed to the various prepared concentrations of each salt, and responses noted. In tests of various salts the results show certain statistical resemblances: when the percentage of animals responding to a salt is plotted against the concentration of the salt administered, an asymmetric sigmoid curve is obtained. Statistically, this is exactly the same result as obtained in tests of the effect of toxic agents on multicellular animals (Bliss, 1950), and it appears to be a general phenomenon in studies on chemoreception, regardless of the type of chemical tested.

The sigmoid dosage-response curve is often rather unwieldy for purposes of later analysis. By expressing the concentration of stimulus as the logarithm of the molar concentration used, and by converting the percentage responses into deviates of the normal curve, or probits, a linear relationship is obtained between the concentration of stimulus administered and the response obtained. The concentration to which fifty per cent of the population responds is customarily chosen as "threshold"

for any stimulus. The theory of probit analysis is given in the book by Finney (1952) and the precise statistical method most generally useful in these studies is presented in detail by Bliss (1938); a shorter procedure, yielding results essentially the same, has been provided by Miller and Tainter (1944).

A short digression here is necessary to emphasize the utility of this method of analysis and its significance. Dethier and Chadwick (1948) have demonstrated that the linear relationship between stimulus and response, when each is expressed as specified above, is obtained with a variety of insects and is true also of those vertebrates for which adequate data have been presented. As an experimental tool, this method is extremely useful, since it permits extrapolation of data to threshold when solubility characteristics or expense of a chemical do not permit tests throughout the entire range of effective concentrations.

To return to the salts, which provide a convenient example, let us suppose that two series are tested: one of sodium salts, and one of chlorides. These groups might include the following:

Sodium salts	*Chlorides*
Na I	KCl
Na Br	Na Cl
Na acetate	Li Cl

It will be noted that there is one component of every compound that is shared with other members of its own series. Therefore, the property which is actually being compared in a study of the relative effectiveness of chemicals in each group depends upon the unlike parts of the compounds. The sodium group tests the relative stimulating effectiveness of the I^-, Br^-, and CH_3COO^- components, while the chloride series tests the relative stimulating effectiveness of K^+, Na^+, and Li^+. When this experiment was actually performed, the orders of effectiveness were found to be that given in the listings above. What makes I stimulate in lower concentrations than Br, and Br in lower concentrations than CH_3COO^-? These differences are statistically significant as can be shown by the usual statistical methods. Actually, an adequate explanation has never been given for this series. This, plus other information, has suggested that anions may not be very important influences on the stimulatory powers of compounds, although some unexpected principle may yet be uncovered from these data.

An interesting explanation has been found for the cation series. The relative stimulating effectiveness of these and other cations can be related to their ionic mobilities. In fact, a plot of ionic mobility against threshold concentrations shows a linear relationship. Other properties of the cations which have been tested in this manner show no such relationship to thresholds. Data of this type have been obtained from studies on insects from quite different sorts of environments by Frings (1946) and Hodgson (1951). The correlation of stimulating effectiveness with ionic mobilities

of cations suggests that the limiting factor in chemoreception is some kind of "access to the receptor system". It is not known whether the stimulus merely reaches a receptor cell membrane and is temporarily adsorbed there, or whether in order to be effective the stimulating chemical must penetrate into the receptor cell itself.

In order to determine whether some kind of penetration property also determines the stimulating effectiveness of other compounds as well, the organic alcohols might be tested. If the sensitivity to alcohols differing in length of the main carbon chain is tested with an appropriate insect or other arthropod, the results appear quite startling at first. Large quantities of methyl, ethyl, and propyl alcohols are necessary to evoke threshold reactions. Relatively minute amounts of butyl, amyl, and hexyl alcohols are required. If one prepares a plot of threshold concentrations against number of carbon atoms, it can be seen that a sharp and significant break in the curve appears between propyl and butyl alcohols. What property of the alcohols also shows this peculiar irregularity in distribution? After testing various possibilities, it has been shown that oil-water partition coefficients increase sharply in the longer chain alcohols in precisely the manner observed with the alcohol thresholds. Since the receptor cell membrane presumably contains a high proportion of lipoids, these data also are interpreted as evidence that penetration to the site of action is the limiting factor in chemoreception. This has been demonstrated for insects from various environments (Dethier and Chadwick, 1948; Hodgson, 1951), and for various other arthropods.

What bearing do these findings have on human "taste" reception? Comparisons of the invertebrate data with those obtained from human tests are not very extensive because human subjects cannot be safely exposed to many of the chemicals tested on invertebrates. However, the comparisons thus far available indicate that the factors limiting the effectiveness of stimulation of chemoreceptors in man and invertebrates are the same. The most extensive comparison of the physiology of human receptors with those of invertebrates has been made by Dethier (1951), using homologous aliphatic glycols as test substances. When stimulating either the chemoreceptors of the human tongue or the tarsal chemoreceptors of the blowfly, threshold concentrations of glycols decrease logarithmically as the carbon chain is lengthened. It is encouraging to know that in a field beset with many impediments to experimentation, results obtained on the more easily handled experimental animals may have general significance for other organisms as well.

To summarize, the insects and other invertebrates are excellent experimental material for the study of chemoreception because of (1) accessible, localized receptors without overlying coatings, and (2) the availability of large numbers of animals, permitting rigorous statistical characterization of the sensitivity of a population of animals. The method of testing the stimulating capacity of chemicals and the probit-analysis treatment of the data have been discussed. The generalizations which can be formulated in harmony with these results are believed to be of general significance for understanding chemoreception in other organisms, including man.

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Physiological Aspects of Testing Contact Chemoreception. A Symposium

CONCEPTS OF CONTACT CHEMORECEPTION IN MAMMALS AND MAN[1]

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The fact that chemical sense organs are grouped together at the entrance to the respiratory and alimentary tracts of mammals and man means that these senses are frequently stimulated in combination. The contribution of each of these senses to the complex experience we call flavor or "taste" of food may be ascertained only by analytical study. These perceptions are further complicated by other components such as warmth, cold, touch, and pressure. In man, the order of decreasing sensitivity of the chemical sensory organ is smell, taste, and common chemical sense. In general or comparative use though, these terms should connote chemoreceptors of particular sensitivities rather than particular sensations. Thus, Parker and Stabler (1913) showed that for man grain alcohol had an olfactory threshold of 0.000125 molar solution, a gustatory threshold of 3.0 molar solution, and a common chemical sense threshold of 5.0-10.0 molar solution.

We may then, for purposes of discussion, follow Dethier and Chadwick's (1948) suggestion that contact chemoreceptors are stimulated by substances in solution; e.g., the taste buds and simple end-organs of the general chemical sense. The latter receptors may be disposed of by recalling that above a certain concentration grain alcohol is irritating or painful to the soft lining membranes of mouth and throat, whereas just below this concentration it is tolerated, and is enjoyed by many at milder concentrations. The evidence for this primitive modality of sensation is perhaps best exemplified by the reaction of insects. For them most substances are optimally attractive at a particular concentration and decrease progressively as the concentration increases (the attraction changing to repellency).

Since investigators of the fundamentals of chemoreception have long felt that precise determinations of threshold values, statistical concepts in themselves, would contribute to an understanding of the nature of the adequate stimulus, much of this work has been done on taste. For instance, man is sensitive (Pfaffmann, 1951) to the extremely bitter compound, quinine hydrochloride, at the approximate minimum concentration of 1.5×10^{-5} molar solution; he is sensitive to the sour compound, hydro-

[1] See footnote on page 14.

[2] Paper received August 31, 1954.

chloric acid, at 1.25 x 10^{-3} molar solution; he is sensitive to the salty compound, sodium chloride, at 9 x 10^{-3} molar solution; and he is sensitive to sweet cane sugar, sucrose, at 2 x 10^{-2} molar solution.

Consequently, it will aid us to consider the meaning of these classes of sapid compounds and the degree of refinement of experimental and statistical controls achieved or deemed adequate for theorizing about gustatory function and its applications. While the taste buds in the tongues of man, rat and cat contain receptors that look alike in microscopic preparations, experimental methods which we may term *punctiform* and *direct* have demonstrated physiological types. Punctiform exploration of the human can be done simply by applying a pure solution with a tiny camel's hair brush to many discrete sites on the tongue. The result of many tests with many pure solutions is a map comprised of four areas that are of the lowest threshold for bitter, sour, salty and sweet sensations. These, then, are the total number of submodalities of taste which are more or less localized in different regions of the tongue, differing in position by as much as several centimeters. This arrangement permits an opportunity for experimentation which has been only partially exploited. Since there is considerable overlapping, we should think of the regions as quantitatively delineated. The receptors for sweet and salt are near the tip, those for sour are on the back lateral surfaces, whilst those for bitter are towards the back upper surface. A more controlled method of stimulation, however, is by means of an insulated burette arrangement from which a fine stream of the test solution is directed on the tongue, thus keeping the mechanical stimulation of the different solutions constant (Zotterman, 1949).

Richter (1943) discussed a preference or choice technique for threshold determination, devised by Richter and Clisby (1941), that is essentially the same for rats and humans, except the latter subjects gave oral descriptions of their taste reactions. The design utilized three of the submodalities of taste. The subjects were permitted to sip or drink liquids, the rats from a pair of bottles and the humans from a pair of 2-ounce glasses. The rats were caged separately and the humans faced the experimenter across a table one at a time. One unknown liquid was distilled water, the other was a pure solution of sodium chloride, cane sugar, or phenylthiocarbamide (phenylthiourea) — a very bitter tasting substance which has a highly toxic effect on rats, 1 to 2 milligrams being sufficient to kill them in only a few hours. The stimulus was first presented in so low a concentration to the rats as to make it indistinguishable from distilled water, and on successive days the concentration was increased in small steps. Of the 23 male and 24 female rats tested, all of them eventually accepted or rejected (drank less of) a concentration of the solutions. This level was below the lethal dose for the poison. This acceptance or rejection value was taken as the taste threshold as it was an indication of recognition of difference between the solutions and distilled water. Of the 139 male and 122 female humans tested, when a subject definitely stated that one glass had a bitter, salty or sweet taste the test was discontinued. If the subject could not taste a 0.25 per cent solution of phenyl-

thiocarbamide, he was regarded as "taste-blind". Many concentrations were presented to the humans in one day.

For sodium chloride rats had a threshold of 0.055 gram per cent and humans had one of 0.087 per cent, but noticed a difference at 0.016 per cent. For sucrose rats exhibited a preference at 0.5 per cent and humans recognized "sweet" taste at 0.41 per cent, but noticed a difference at 0.17 per cent. For phenylthiocarbamide rats had a mean rejection value of 0.0003 per cent with a range of 0.00005 to 0.02 per cent. Humans had the same mean threshold for this substance with a range of 0.00001 to 0.2 per cent. Thus, an astonishingly close relationship between rats and humans was found, having virtually the same thresholds with the difference that humans showed a wider range of individual variation. Richter carried these experiments much farther by providing rats with all the raw materials of a healthful diet and demonstrating that an innate specific appetite, functioning in part through the taste buds, provided self-regulation of the steady, physiological state (good health).

The problem of determining the absolute taste thresholds was not solved by the preference method. Patton and Ruch (1944) stated that the failure of normal rats to select salt solutions weaker than 0.055 per cent does not necessarily mean that the salt cannot be detected, but rather that the motivation is insufficient to force the animal to make such difficult discriminations. Due to the interest engendered by the knowledge that humans exhibit great differences between individuals for sensitivity to phenylthiourea (phenylthiocarbamide), Harris and Kalmus (1949) devised a method for determination of the absolute threshold. One of the difficulties that arises out of presenting subjects with increasing concentrations of phenylthiourea and recording their responses is that people differ in the degree of sensation which they consider to be a positive taste. A further difficulty is that different subjects, particularly near their threshold, record very different sensations; for example, besides bitter they may refer to the taste as sweet, sour, salty, astringent, like flat water and so on. These difficulties were surmounted by determining the lowest concentration of the substance which a subject can discriminate from water. The experimental design is based on the classical tea experiment of R. A. Fisher.

A stock solution containing 0.13 per cent phenylthiourea is made up in boiled tap water and serial dilutions are made up from 1300 milligrams per liter to 0.16 milligrams per liter in fourteen steps.

(1) Starting from the higher dilutions and working down, the subject is given a few cc. in a tumbler till he first says that he perceives a definite taste.

(2) Then eight tumblers are presented, four of which contain a few cc. of water and four contain the solution determined in stage one. The glasses are arranged at random. The subject is told that four contain water and four the substance. If the two groups are correctly separated the test is repeated with the next lower concentration and so on, until the subject can no longer discriminate correctly. The lowest concentration at which a completely correct answer is given is taken as the threshold. If the initial separation is not entirely correct, the process is repeated in

reverse by presenting increasing concentrations until the correct answer is given.

Harris and Kalmus found that consistent results were produced and that in 441 boys and men taste sensitivity decreased with increasing age. This was true for both tasters and non tasters. Among the tasters, the 10-19 year olds had a mean threshold of 2.54 milligrams per liter of water; the 20-49 year olds had between 2.54 and 5.08 milligrams per liter; and the 50+ year olds had 10.16 milligrams per liter. Thresholds for the respective age classes of non-tasters were 6 to 7 serial dilutions more concentrated. Verification of earlier work showed that women had a slightly greater taste sensitivity for phenylthiourea than men.

The direct method of typing the taste receptors and determining thresholds was utilized by Pfaffmann (1941) in the cat. He attached electrodes to the appropriate gustatory nerve conducting impulses from the taste buds and recorded electrical impulses by means of a Matthews oscillograph. The apparatus gives a photographic record. Since these were single fiber recordings of the magnitude and frequency of impulses arising immediately after stimulation of the tongue by pure solutions with a small brush, some doubt is cast on the discrete nature of the taste receptors. No doubt about the fact of stimulation by a given solution of known concentration can be entertained. Pfaffmann found that the cat has three types of fibers in its taste-nerve: (a) responds to acid only, (b) responds to acid and sodium chloride, and (c) responds to acid and quinine. No fibers responding to sugar were found, but a map or zonal distribution of (a), (b), and (c) was delineated. A salt-quinine fiber was not found. Of much interest is that acid was an effective stimulus of all types of gustatory endings, while salt and quinine sensitivity do not exist independently, but always in conjunction with the hydrogen ions.

The theory supported by this direct evidence from a series of cats is that sodium chloride and quinine each stimulate a different group of receptors. Discrimination between these two substances presumably depends on the fact that impulses reach the central nervous system in two different sets of fibers. Since hydrogen ions, by dissociation of the acid, activate all receptors, sour must be discriminated from sodium chloride because acid produces simultaneous activity in all fibers as opposed to activity in one fiber group. If we carry over this mechanism *to the human*, we might say that a discharge of impulses in one set of fibers will produce salt, whereas discharges in the *same* fibers combined with activity in all the remaining gustatory fibers will produce sour. In such a system, sensory quality does not depend simply on the "all or nothing" activation of some particular fiber group alone, but on the pattern of other fibers which are active.

Since Richter thought that lowered salt concentration of the blood caused by removal of the adrenal glands would lower the threshold for salt, Pfaffmann and Bare (1949) showed by the direct method (or method of choice in studying the physiology of chemoreception) that the average threshold for salt was the same for normal rats and adrenalectomized subjects. This result suggests that salt needy rats display a preference as

soon as they can taste salt, rather than Richter's tentative suggestion that threshold is somehow determined by the blood concentration of sodium chloride.

However, Richter's postulate that taste has a primary biological value is supported by Davis' (1939) findings on fifteen human infants of weaning age. When presented with all the natural foods necessary for maintenance of the body, these inexperienced infants, by self-selection, chose fifteen different diets that sustained good health for four years, this being the longest period Davis experimented. She concluded that selective appetite is, primarily, the desire for foods that please by smelling or tasting good. In a few days, these infants developed patterns of selective appetite on the basis of sensory experience and a feeling of comfort and well-being following eating.

On the complicated and elusive topic of the mechanism of taste receptor activation much has been written, but an adequate consideration of it must be sought through investigation of cellular changes in the sensory end-organ itself, a difficult and challenging problem. We know that stimulation requires the contact of the solution with the receptor —— just what happens next is not known. One looks to the newer applications of creative statistics as well as to more refined apparatus and ingenious skills for needed guidance or tools.

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Physiological Aspects of Testing Contact Chemoreception. A Symposium

FLAVOR PERCEPTION BY CONSUMERS [1]

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Without recourse to anthropology, most of us have observed that food habits, the likes and dislikes of individuals, are often unpredictable and highly whimsical. Some of the whimsy may have been due formerly to large variations in food quality, which today are less noticeable as a result of increasing standardization of processed fods. The trend toward standardization has been paralleled by the trend toward mass production and distribution. All of these factors have increased the financial risks resulting from mistaken or biased flavor judgment on the part of the food packer who wants to "improve" his products or introduce new prdoucts. Consequently, more and more of us in the food business are bolstering our marketing decisions by some sort of statistical flavor evaluation. The statistical approach has been added to that of the expert taster, as traditionally employed by producers of tea, coffee, beer, and wine. The expert is respected for his ability to discriminate and describe flavor differences and to relate them to trade standards. However, the traditonal expert's prediction of consumer opinion can often be biased and his errors remain undetected until too late if they are not frequently audited by a statistical check with trained panels or by consumer sampling.

Use of Laboratory Panels.——Taste panels are usually organized from laboratory or office staff members by a process of screening. For example, if the panel is to assess coffee quality, a group of about 30 candidates are presented first with known samples to demonstrate varying degrees of freshness, roast, varietal characters, etc. The same samples are later presented under blind code for identification of small differences by means of the triangular test —— two identical samples plus one odd sample —— for identification of the odd sample. Tests are set up to cover all the known commercially important variables and are repeated on different days. At the end of 20 to 30 such screening tests, the most successful 10 or 15 persons are selected as an operating coffee panel. Reference will be made later to the relative acuity of such a panel and of large consumer panels.

The function of a laboratory panel may be:

(1) to detect any departure from standard quality, or to assess flavor intensity in terms of known standards (quality control)

[1] See footnote on page 14.
* Paper received August 31, 1954.

(2) to subjectively analyze a complex flavor into its attributes and to evaluate their relative intensities (flavor profile).

To illustrate one use of a panel, let us suppose that a research group has discovered a new way to formulate a flavor for a dessert product. Let us assume that there are several alternate directions in which this project can move, and it is desired to know whether this particular one should be pursued or dropped. Our first step is to determine whether the experimental sample really differs significantly from the standard. The new and standard products are submitted to a screened panel in a triangle test. If fewer than nine tasters out of a panel of 15 succeed in the correct identification, the experimental sample is judged to be so close to the standard that no further testing or development in this direction is warranted. Parenthetically, the question is frequently asked why the judgments of tasters who are unable to identify the odd sample should not be rejected. This can be answered by considering what happens if all three samples are identical. On the average, one-third of the tasters will succeed and two-thirds will fail to identify a designated sample, by chance alone. The point that is often overlooked is that correct identification can be an accident as well as an indication of taste sensitivity. This risk is properly assessed by statistical treatment of *all* the individual judgments.

It is often important to know whether a process change has produced a slight difference in flavor character. In such cases it is important to demonstrate the taste character to be determined, so that all tasters are agreed on the terms in which to express their opinions, before final selection of the screened panel. For example, the characteristics of bitterness and astringency are both important, but are difficult for the average taster to distinguish. In our experience, it was not until demonstrations were set up, using quinine and tannin solutions as models, that many panel members were able to assign the proper descriptive terms to the flavors they perceived.

It is also important to recognize that a panel judgment regarding the intensity of a specific flavor character does not necessarily provide any information as to how well the consumer will accept the product. We have discouraged the use of laboratory panels to measure preference alone, because of the unknown effects of individual prejudice and whimsy in such a small group. In general, we prefer to use the laboratory panel as an analytical tool to detect differences and to measure relative flavor intensities, leaving to the consumer panels the decision as to what the consumer likes.

Fatigue.—The effect generally known as fatigue has been discussed subjectively by many writers in the field of sensory evaluation. In organoleptic testing, it is characterized by diminishing ability of a taster to recognize small differences in flavor as tasting is prolonged.

In our laboratory, triangular tests are used extensively for routine difference evaluation of experimental and standard products. In order to obtain a maximum number of judgments and at the same time keep the cost of testing-low, two triangular tests are presented at one sitting.

Over the period of a year and a half, we have accumulated the results of 148 double triangular tests on a coffee product by an expert panel. In all of these, the sample pairs were the same for both triangles. In half of the tests, the odd sample of the first triangle was presented as the duplicated sample in the second triangle. In the other half, the odd sample of the first triangle remained the odd sample in the second.

These 148 sets of successive tests were compiled and tabulated into the contingencies shown in Table I.

TABLE I.—SUMMARY OF THE NUMBER OF SUCCESSES AND FAILURES IN A SERIES OF DOUBLE TRIANGULAR TESTS

Results	*First Triangle*	*Second Triangle*	*Both*
Successes	856	880	1736
Failures	863	839	1702
Total	1719	1719	3438

It is apparent that there is no lessening in sensitivity due to fatigue in this series. In fact, the total number of successes in the second set of triangles is even greater than in the first.

Fatigue has been evaluated under similar conditions for maple syrup. This product is considered by our trained panel to be one of the most difficult to taste because of its high level of sweetness.

A series of tests on blended maple syrup was conducted using double triangular tests. Results of this series of tests are shown in Table II.

TABLE II.—SUMMARY OF THE NUMBER OF SUCCESSES AND FAILURES IN A SERIES OF DOUBLE TRIANGULAR TESTS ON MAPLE SYRUP

Results	*First Triangle*	*Second Triangle*	*Both*
Successes	97	75	172
Failures	70	92	162
Total	167	167	334

The difference in results between the first and second triangles was examined by X^2 analysis and found to be significant at the 2% level. This definitely suggests that fatigue was operating, since all other factors of variation were either randomized or controlled.

Consumer Tests.—As mentioned earlier, an analytical panel does not necessarily reflect consumer preference. When an experimental sample has been judged to be significantly different from the standard, yet not obviously defective, we have recourse to a short-cut method of consumer sampling. The control sample and an experimental variant are sent to one or another of several New York department stores where space is rented for this work. A staff of two to four trained interviewers invites customers of the store to participate in a "taste test". The respondents are asked to tell which of two blind-coded samples they prefer and, if possible, the reason for their choice.

The information thus obtained is used as a day-to-day or week-to-week source of guidance for the technologist attempting to improve old or develop new products. Principal advantages of this store test procedure lie in the relative speed with which results can be obtained and the compartively low cost.

It has become standard practice to obtain at least 300 consumer judgments on a sample pair before concluding that a preference has or has not been demonstrated. Usually this can be done in one day's time.

Correlation of Panel and Consumer Tests.——During a two-year period we had occasion to examine about 76 different sample pairs of coffee by both laboratory panel and by store test. A breakdown of what occurred in these 76 matched tests is shown in Table III.

TABLE III.——COMPARISON OF PANEL AND CONSUMER PERFORMANCE

	Number	*Per cent*
Total Tests	76	100
Consumer Preferences	25	33
Panel Differences	30	40
Total Consumer Preferences	25	100
Panel Differences	15	60
Panel Failures	10	40

The interesting part of Table III is the breakdown of the 25 cases in which consumers found a preference. It is not surprising for consumers to fail to show a preference for one of a pair of samples which a panel has found to be different. It is surprising at first glance for consumers to find a preference where a panel has failed to find a difference. Table III shows that this occurred 10 times (40%) in 25 cases of consumer preference.

The 5% significance level is not reached in a 300 judgment test until a preference of at least 55.7% for one sample is realized. In the 10 cases shown in Table III where the panel failed to find a difference, the average percent preference found in the consumer test was 58.3%. The range was 56.5% to 65.5%.

The question may be raised as to whether or not the expert panel we used was actually large enough in size for the task assigned to it. Table IV shows the number of tasters participating in the 10 cases of panel failure, together with the percentage success in each test.

It is interesting to note that Tests 3 and 9 were at chance level of 33% or below. For these tests, no increase in panel size, assuming the same percentage success, would ever yield a significant result. A simple calculation shows, however, that if a panel of 120 tasters had the same degree of success as shown in Table IV, eight of these cases of failure would have been considered to have shown a significant difference.

This indicates that, for this type of sample, under the conditions of testing described earlier, a panel test of at least 120 judgments is needed

to avoid the risk of missing differences corresponding to an average consumer preference of 58%.

TABLE IV.—RESULTS OF EXPERT PANEL WHICH WERE CONSIDERED FAILURES

Test No.	*Expert Panel Size*	*Expert Panel % Success*	*Level of Significance*
1	26	42	.50
2	14	50	.30
3	16	31	>.50
4	22	46	.30
5	26	46	.30
6	13	62	.06
7	14	43	>.50
8	13	62	.06
9	48	33	>.50
10	14	50	.40

These findings seem reasonable when one considers that the panel was selected as above average from twice its number of unscreened selectees. With an added advantage of training and experience in tasting, 120 judgments by this group is found to compensate for the added statistical advantage of 300 inexperienced consumers. This is a "sensitivity ratio" of about 1 to 3. By comparison, when researchers use panel tests of 15 to 30 judgments, a sensitivity ratio of 1 to 10 or 20 is required.

Consistency of Store Test Results and Correlation with Home Use Tests.—Although store test panels of at least 300 are recommended, it has been our practice to schedule the tests in units of 150 judgments each. Frequently the two halves of a test are run in different stores. Although the unit scheduling is governed by expediency rather than by deliberate randomization, it has been found that the differences between half-test results for a given sample pair do conform to the normal distribution of random error. Based on a total of 200,000 judgments accumulated over a period of 18 months, the error estimate for a 300 judgment paired preference is 10 percentage points.

When store test results appear encouraging, we usually recommend a nationwide consumer sampling by mail before changes in merchandising plans are authorized. Paired comparisons in the home are known to be subject to many more uncontrolled variables than are the local store tests, but they have the advantage of better representing, on the average, the actual conditons of use.

Statistical analyses are in progress to establish the expected error of a home use test and the correlation between store tests and home use. At present it can be said that, for the majority of products tested, the

store test provides a valid estimate of consumer acceptance, within the rather wide range of error which is characteristic of such sampling.

In all of the foregoing it is assumed that our objective is to win consumer acceptance over a standard or competitive product of high acceptability. It is interesting to speculate what would happen if a radically new (but not obviously objectionable) type of flavor were to be appraised. It is very probable that the techniques just described would never succeed in establishing a majority consumer acceptance for such a product. This would be expected for two reasons — (1) the unavailability of a standard having reasonably close resemblance to the new product, and (2) its probable rejection by the consumer because of lack of familiarity with the type. A decision to promote such a product today would require unusual courage, because no valid estimate of risk could be obtained until some degree of "consumer education" had been attained.

Velocity of Propagation of Luminosity in Long Discharge Tubes [1]

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The propagation of luminosity and potential in long discharge tubes has been investigated by Thomson (1893), Beams (1930), Snoddy et al. (1936, 1937), Mitchell et al. (1947). The work to date has shown that the luminosity has the same propagation characteristics as the potential pulse; that it moves always from the high potential electrode; that the first discharge may be followed by a second of higher luminosity which originates at the low voltage electrode if the latter is grounded; that the velocity is highly dependent on voltage and pressure, showing a definite peak at some pressure which is characteristic of the gas. These characteristics are similar to the observed features of the lighting discharge (Schonland et al., 1934) and the long sparks which may be produced in high voltage laboratories (Allibone et al., 1938).

The present investigation of velocity characteristics of luminous discharges was undertaken to extend observations previously made in this laboratory (Beams, 1930; Snoddy et al., 1936, 1937; Mitchell et al., 1947). The velocity of the luminous pulse in discharge tubes 10 feet long, supported coaxially in 6 inch gutter pipe, was determined for air, argon, carbon dioxide, helium, hydrogen, nitrogen, and oxygen as a function of pressure, voltage, and electrode shape. Two tubes were used, of 6 and 12 mm. inside diameter.

APPARATUS

The arrangement of the equipment used is indicated in the block diagram, Figure 1.

The high voltage power supply was a Marx circuit (Jacob, 1934: 7) which was calibrated by spark gap measurements.

The time interval between arrival of the luminosity at two points in the discharge tube was measured by means of photomultiplier tubes and a 300 ohm Twinlead transmission line along which 16 detector circuits such as are shown in Figure 2 were spaced at 2 foot intervals. This is a modification of the "chronotron" described by Keuffel (1949). The operation is as follows: when a negative signal is sent down the transmission line each detector produces an output pulse about 0.4 microsecond in length. These pulses are delayed 0.5 microsecond with respect to one another by delay lines and are then presented on a synchroscope. When

[*] Paper received September 5, 1954.
[1] Supported by Navy Bureau of Ordnance Contract Nord.-7873.
[2] Now at United Gas Corporation, Shreveport, Louisiana.

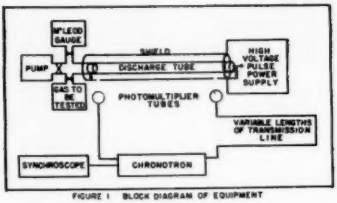


FIGURE 1 BLOCK DIAGRAM OF EQUIPMENT

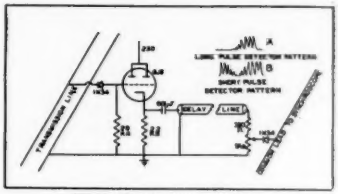


FIGURE 2 CIRCUIT DIAGRAM OF DETECTOR

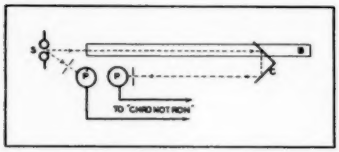


FIGURE 3 CALIBRATION DEVICE

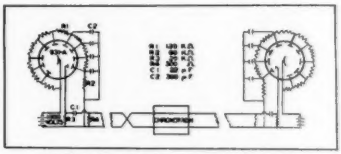
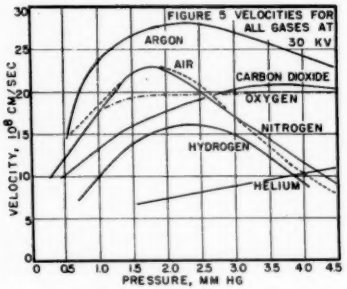
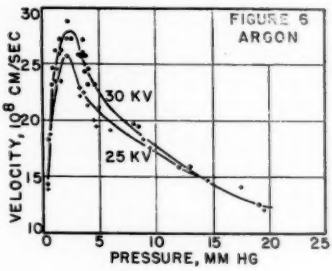
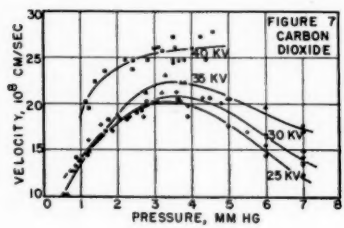
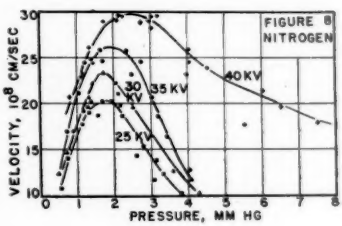


FIGURE 4 CIRCUIT DIAGRAM OF PHOTOMULTIPLIER TUBES









a positive signal is sent down the transmission line, the response of the detectors is too low to be observed, due to the polarity of the 1N34 crystals. If a positive signal is sent from one direction and a negative signal from the other, all of the detectors produce pulses except the ones on which the two signals are impressed simultaneously. An estimate of the signal length can be made, based on the contour of the pulse heights. This is apparent when one considers that a full negative signal is not presented to the detectors at some time only where the two signals are coincident in time and space. Hence in sketch A of Figure 2 one sees at once that the signals were longer than half the time interval represented by the detector spread, and that in sketch B the signals were coincident at seven detectors. If one of the transmission line signals is delayed with respect to the other, the meeting point will shift with a corresponding change in the output pattern of the detectors. By inserting known lengths of transmission line, using polarized connectors, the two signals can be made to meet at any detector desired, greatly extending the range of the instrument.

The system was calibrated with respect to the velocity of light in air by use of a spark gap and an optical bench as shown in Figure 3. By changing the position of the optical corner, C, known time delays could be introduced into either signal to the detector circuits. The corresponding shift in meeting point of the signals could be recorded, or the signal pulses could be made to meet at the same detector as before by inserting various lengths of transmission line. This procedure established the fact that the detectors did not change the velocity of signals on the Twinlead transmision line to a noticeable degree. The velocity on the transmission line of a signal with a rise time of 3×10^{-9} seconds was 0.92 times the velocity of light in air. Rise time as used here indicates the time from zero to maximum signal, as determined from the synchroscope pattern. It was found that the detectors functioned properly with a minimum of 3 inches separation, a limit set by the physical spacing of the detectors on the chassis. In the present work the 2-foot spacing of the detectors made it possible to read time intervals to an accuracy of 1.1×10^{-9} seconds, assuming the proper zero time.

The arrival of luminosity at any point in the discharge tube was recorded by means of 931-A photomultiplier tubes, the circuits for which are shown in Figure 4. Separate battery power supplies were used to present signals of opposite polarity but otherwise similar characteristics to the detector circuits. A slit arrangement limited the field of view of the photomultiplier tubes to about 1 mm. The photomultiplier tubes were spaced 7.0 feet apart, at 30 and 8 inches from the high and low voltage electrodes, respectively. A preliminary investigation of velocity as a function of position along the discharge tube showed that erratic effects observed in the first 40 cm (Beams, 1930) were not noticeable in the section used.

The various parts of the vacuum system could be isolated from one another as shown in Figure 1. A dry ice-alcohol cold trap was used to prevent mercury contamination from the McLeod gauge used to measure pressures.

Before taking data on any gas it was necessary to flush the system

several times. A fresh sample of gas was used for each observation, the system being pumped between discharges. The velocity of the luminous pulse fluctuated widely if this was not done. Velocity readings repeated, however, if the tube remained quiescent for some five minutes between discharges. The gases used were of standard commercial purity.

The low voltage electrode was normally connected to the ground through a 5000 ohm electrolytic resistor. If this resistor was shorted out, a luminous pulse was observed to originate at this grounded electrode up to 20 microseconds after the arrival of the initial pulse.

RESULTS

The data are presented in graphical form in figures 5-14. All data shown were obtained with a 12 mm. diameter spherically ended brass electrode in the 12 mm. tube and a similar 6 mm. electrode in the 6 mm. tube. Unless otherwise specified, the data are those taken in the 12 mm. tube.

A conical (20°) high voltage electrode produced velocities much lower than did spherical electrodes; the curves were similar to those obtained with spherical electrodes at lower input potentials.

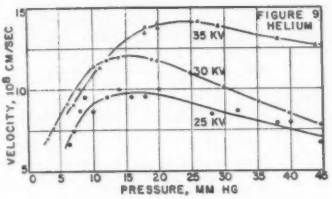
The spread of values of the data appears to be largely due to operator error in observing time intervals when the deviation is greater than the accuracy of the "chronotron". This explanation is not satisfactory for the larger deviations; such fluctuations have been noted previously (Snoddy et al., 1936, 1937; Mitchell et al., 1947).

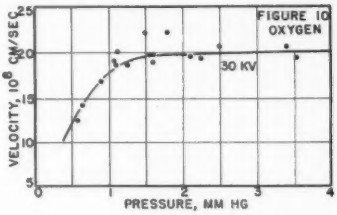
DISCUSSION OF RESULTS

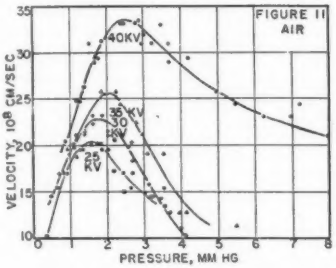
The results of this investigation are in general agreement with the work referred to in the introduction. The principal contribution of this paper is the relative velocities of luminosity in various gases at a given potential, as shown in Figure 5.

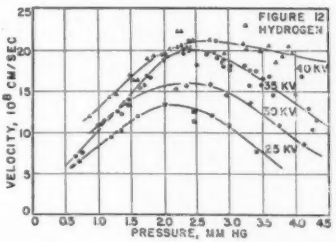
The explanation of this ordering appears to be connected with efficiency of ionization by electrons in the gases. In this respect it is interesting to note the correlation of Figure 5 with plots of α, the first Townsend coefficient, as a function of the energy of incident electrons (Compton et al., 1926: 724; Maxfield et al., 1941: 267). The relative magnitudes of maxima in the two sets of data as well as the two cross-over regions are the most striking points of correspondence.

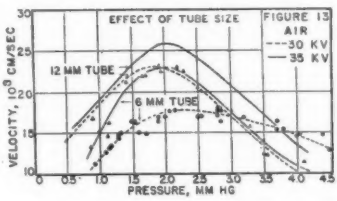
One may construct a relatively simple qualitative description of the mechanism of propagation which explains the observed features of the data. Consider an intermediate point in the discharge tube at which the positive potential has just arrived. The intense luminosity in this region leads to production of photo-electrons in the undisturbed region ahead of the propagating potential front. These electrons are accelerated toward the front, ionizing by collision as they go. Both the conductivity of the discharge tube and the usual treatment of the spherical tipped discharge (Schonland et al., 1934; Meek, 1939) lead to values of ionization of the order of 4×10^{11} ions/cc. One may now make certain assumption as

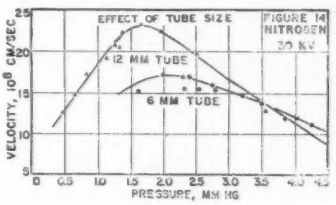


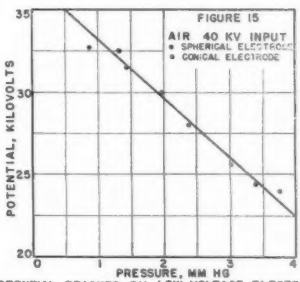












POTENTIAL REACHED BY LOW VOLTAGE ELECTRODE

to the magnitude and gradient of the net charge at any point in the tube. Calculated values of the gradient in volts/cm. for exponential, linear, and constant densities of net charge over various lengths, as well as the hemispherical tip assumption, show that in each case fields may be found over distances which, combined with reasonable values of α, will produce an ionization of 4×10^{11} ions/cc. from a single photoelectron. While the exponential distribution appears to be the most probable one, none is outstanding so far as application to the present problem is concerned.

Assume for the present purpose that the field as a function of distance is the same for each gas at a given pressure (between 1 and 3 mm. of mercury) and potential. Ionization will then be more effective in the low field region for argon than for helium, or the ion density required for propagation of the potential will be developed in shorter distances from the point of origin of the initiating photoelectron, which corresponds to a higher velocity of the potential pulse. At higher potentials the optimum distribution of electron velocities will be attained in shorter mean free paths, or at higher pressures. This appears to be borne out by the shift of the velocity peak to higher pressures as the applied potential increases. As the pressure rises, however, the effective mean free path for photons decreases with a consequent decrease in velocity of the pulse. The preliminary investigation previously mentioned indicated a lower velocity as the luminosity moved away from the high voltage electrode. This is explainable on the basis of a lower potential due to the tube drop. The extent of this drop is indicated in Figure 15, in which the voltage drop across the 5000 ohm low potential resistor is plotted as a function of pressure. Since the input potential was constant, one sees that the tube drop increased linearly with pressure over this range. It should be pointed out in this connection that the velocities measured are of necessity the average velocities for the given conditions.

The extension of this treatment to a more exact quantitative development will require considerable data not yet available in the literature as to absorption coefficients of ionizing radiation in all of the gases, the net charge distribution, and the attenuation effect of the tube walls.

ACKNOWLEDGMENTS

The "chronotron" described in this paper was developed under the direction of the late Dr. L. B. Snoddy. The remainder of the work was done under the direction of Dr. J. W. Beams, Chairman, Department of Physics, University of Virginia. The author wishes to express his gratitude to these gentlemen and to other faculty members and fellow students whose comments and suggestions contributed to the successful completion of this work.

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The X-Bivalent of the Golden Hamster

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The sex chromosomes of the golden hamster, *Mesocricetus auratus*, are larger than the other chromosomes of the complement. At the first meiotic metaphase in the male the x-chromosome is composed of a deeply staining portion, and a less contracted more lightly staining heterochromatic part. The y-chromosome stains deeply in its entirety and is smaller than the x. The deeply staining portion of these chromosomes is the pairing segment, and the more lightly staining portion of the x, the differential segment (Koller, 1938). The retarded development of the differential segment is associated with the formation of gyres smaller in diameter and more numerous than the precociously developed spiral of the pairing segment. A chiasma is found between the long arm of the y and the x in 81.6 percent of the bivalents. The remainder have a second chiasma between the short arm of y and the portion of the x proximal to the differential segment (Koller, 1938).

In spermatogonial divisons the two largest chromosomes, assumed by Koller (1938) to be the x and y, were described as morphologically indistinguishable and having subterminal centromeres. Husted, Hopkins, and Moore (1945) found the two largest chromosomes of oocyte nuclei undergoing mitosis to have clearly submedian centromeres and an arm ratio of 1:1.9. Since the pairing segment of the y-chromosome at meiosis in the male is the longer arm and is seen to be equal in length to the deeply stained portion of the x, and since Koller had reported the x and y indistinguishable in size in spermatogonial divisions, Husted, Hopkins and Moore (1945) concluded that the differential segment of the x when fully contracted is a part of the shorter arm.

In the male, chiasmata can form only between pairing segments of the x and y. In the female where two x-chromosomes occur, it is to be expected that chiasmata may form between differential as well as pairing segments. According to Husted, Hopkins and Moore (1945) the differential segment of the x is not heterochromatic at mitosis and meiosis in the female. This segment resembles the pairing segment in being contracted and also staining deeply. Husted, Hopkins and Moore (1945) have presented evidence, admittedly inconclusive, that chiasmata are localized between the short arms of the x-chromosomes. All of the x-bivalents they encountered, 6 in number, were associated by chiasmata between short arms.

It seems desirable to extend these observations to determine if chiasma localization does in fact exist in the differential segment fo the female hamster. It is with this feature that this paper is primarily concerned.

Paper received August 4, 1954.

MATERIALS AND METHODS

The mammalian ovary has been seldom used in chromosome studies because meiotic and mitotic divisons are less frequently found there than in the testes of the male. The chromosomes in oocytes, however, are more widely spread on the spindle and their structure more easily studied than in the crowded spermatogonial cells and spermatocytes. In hamsters 5-7 weeks of age numerous oocyte nuclei are found undergoing mitosis or meiosis. In older animals the number is reduced considerably. The mitotic divisions occur in follicles that usually, if not always, degenerate. Some of the oocyte nuclei undergoing meiosis will likewise degenerate, but no changes were revealed by the methods here used that must be considered to alter the behavior or structure of the chromosomes.

The ovaries from 20 ether-anesthetized hamsters, ranging in age from 5 weeks to 6 months, were removed and fixed in San Felice's solution for 4 hours. They were washed in 70 per cent alcohol, and stained by means of the Feulgen reaction. After bleaching in SO_2 water, the ovaries were dehydrated in ethyl alcohol, cleared in chloroform, embedded in paraffin and sectioned at 30 μ.

The testes from two sexually mature males were removed and cut into small pieces. The material from one male was immediately fixed in Carnoy, while portions of the other were placed in hypotonic solutions of sodium chloride for 20 minutes before fixation. Pretreatment with 0.5 percent sodium chloride facilitated the spreading of the chromosomes. Four drops of 4 percent iron alum for each 10 ml. of fixative intensified the staining of the chromosomes with aceto-carmine.

Observations were made with a Zeiss microscope equipped with 10x, 20x, and 30x oculars and 90x (n.a.1.3) oil immersion objective. Drawings were made with the aid of a camera lucida.

OBSERVATIONS AND CONCLUSIONS

The somatic chromosome number of the golden hamster is 44 (Figures 1 A and B). This is in agreement with the determination in the female made by Husted, Hopkins and Moore (1945) and in the male by Matthey (1951) and Sachs (1952) but contrary to the reports of Koller (1938, 1946) and Muldal (1948).

The male.---The largest chromosome in the male complement (Figures 1 A and 3) measures approximately 7.1 μ in length and is submedianly constricted. The next largest measures approximately 6.5 μ and is easily distinguishable from the former. The difference between these two chromosomes is seen not in their longer arms which are equal in length, but in their shorter arms, (Figure 3). Since these chromosomes are unequal in size, and the largest, and meiotic studies in the male show that the heteromorphic bivalent which is considered the x-y bivalent is the largest of the complement, it is apparent that these chromosomes seen in spermatogonial divisions are the x and y.

The differential segment, which is seen as a less contracted, lightly staining region of the x at meiosis in the male (Figure 2, A and B),

X
Y
1
A
B
A
2
B
3
4

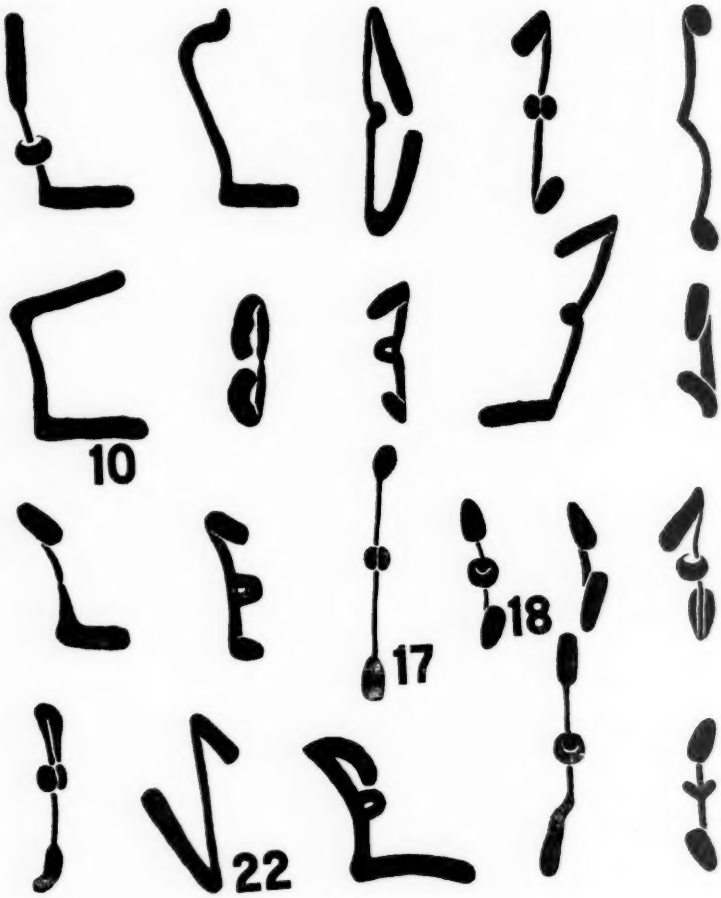
does not stain lightly in spermatogonial divisions (Figures 1 A, and 3) nor is it less contracted. Since the arm of the x that stains deeply, and the long arm of the y are equal in length, and since in spermatogonial divisions the difference between the largest chromosomes designated the x and y is found to be only in their short arms, we must conclude that the differential segment of the x-chromosome is represented in the spermatogonial cells as the difference in length of the *short arm* of the x and y. The differential segment when contracted represents approximately 0.5 μ or 7 percent of the length of the entire chromosome.

The Female.——In the female the two largest chromosomes at mitotic metaphase are submedianly constricted as seen in the only polar view of metaphase that has been found in the course of this study. Husted, Hopkins and Moore (1945) have reported two divisions of this kind which likewise show the largest chromosomes to be submedianly constricted. In both the present account and the one here cited the short arms of the largest chromosomes are longer than the short arm of the chromosome that has been designated the y in the male. It seems clear that these two chromosomes in the female are the same as the one that has been designated the x in the male.

The differential segment, which stains intensely and is contracted in the spermatogonial cells of the male, stains similarly in the oocyte. There is a suggestion, as seen in Figure 1 B that the short arm of the x is less contracted in the mitosis of the female than in the spermatogonial cells of the male, (Fig. 1 A). Although there may possibly be a tendency here for less complete contraction, the staining reaction in all parts of the chromosome is the same.

Chiasma localization.——Oocytes undergo the first meiotic division in various parts of the ovary. In all of these suitable for study, 40 in number, the largest chromosomes, here designated the x-bivalent, are associated by one or more chiasmata between the shorter of the two arms (Figures 4-25). The x-bivalents illustrated here have their long arms in many cases foreshortened and their short arms attenuated as a result of anaphase movement. In each case where foreshortening occurs the method of Levitsky was used to determine the actual length of the foreshortened arm. Figure 10 shows an x-bivalent which lies in one plane while Figure 22 has the free arm at the upper end and to the right greatly foreshortened. Both free arms of this, and of all the other bivalents, are equal in length. Figures 17 and 18 are examples of x-bivalents with both free arms greatly foreshortened. In no oocyte were x-chromosomes associated by long arms nor were any ring bivalents found. There is in the female hamster complete or nearly complete localization of chiasmata in the shorter arm. This is the arm which is considered to include the differential segment.

Chiasma frequency.——In the male hamster, Koller (1938) has found that 8.3 percent of the x- and y-chromosomes fail to form chiasmata and are unpaired at metaphase. In the female, no unpaired chromosomes were encountered. In the male, the average chiasma frequency in the xy-bival-


10
17
18
22

ent is reported to be 1.08 (Table I), while the average frequency in the autosomal bivalents is 1.33 (Koller, 1938).

TABLE I.—CHIASMA FREQUENCY IN MALE AND FEMALE HAMSTERS

Sex	*Bivalents*	*No. of Bivalents*	*Total Chiasmata*	*Chiasma freq. per bivalent*
Male*	xy	276	300	1.08
	Autosomal	180	240	1.33
Female	xx	40	55	1.38
	Autosomal	132	193	1.46

In the female the 40 x-bivalents studied showed 1.38 as the average number of chiasmata between short arms. The autosomal bivalents had a mean chiasma frequency of 1.46. There are more chiasmata formed between both x-chromosomes and between autosomal bivalents in the female than in the male. This is in agreement with the cytological results found by Koller (1932) in the mouse.

The conclusion has been reached that in the female hamster chiasmata are localized between arms which include the differential segment, and that the arms which constitute the major portion of the pairing segment in the male, fail to form chiasmata in the female.

There is only one alternative to this conclusion: namely, that the chiasmata of the x-bivalents are localized between the arms which represent the pairing segment. This alternative demands the assumption that in the female hamster the long arm of the x-chromosome (the pairing segment) contracts differentially and to such an extent that it appears to be a short rather than a long arm. Since there is no evidence for extreme contraction of the x-bivalent relative to the autosomal bivalents this assumption is considered unlikely.

SUMMARY

The x-chromosome of the golden hamster at meiosis in the male consists of a deeply staining pairing segment and a more lightly staining, slender, elongated differential segment. At the spermatogonial divisions the entire x-chromosome is contracted and stains uniformly. The differential segment in these divisions represents approximately 7 percent of the x-chromosome and is indistinguishable from the pairing segment. In the female hamster, the two x-chromosmes are uniformly contracted and the differential segment is indistinguishabel as in the spermatogonial mitosis. Chiasmata at meiosis are formed only between the short arms of the x-chromosomes and hence are localized in those arms which are partly made up of the differential segment. The arm of the x, which in its entirety has no counterpart in the y and consequently the distal portion of which cannot undergo crossing over in the male, is the arm in which chiasmata are localized in the female.

* Data from Koller, 1938.

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The XY-Bivalent in *Chinchilla laniger*

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Chinchilla laniger is a small rodent native to the South American Andes. Its soft, thick fur has led to its domestication and introduction into the United States where it now has become of some economic importance.

The chromosomes are known only through the work of Makino (1953) who has reported the diploid number to be 64 and has designated the X and Y chromosomes at metaphase in a spermatogonial cell. Makino has also reported a "heteromorphic XY-complex which consists of a larger v-shaped X and a smaller v-shaped Y coming into contact by their shorter arms."

Through the kindness of Gordon F. Harris (Charlottesville), C. W. Haga (Front Royal) and Tom Farrow (New Market), Virginia, the material was made available to study the chromosomes in the male and to some extent in the female animal. The results of this study are not in agreement with the conclusions of Makino and furthermore show a striking similarity between the sex bivalent of the Chinchilla and the Golden Hamster as described by Koller (1938).

Testes were removed from ether anesthetized animals and immediately fixed in the 6:3:1 solution of Carnoy while being teased into small pieces. The tubules were refrigerated until ready for staining by means of the aceto-carmine technique of Painter (1939). Observations were made with a microscope equipped with 10x and 15x oculars and a 95x (n.a. 1.25) oil immersion objective. All drawings were made at table level with the aid of a camera lucida and are reproduced at a magnification of 2366x.

Fourteen sex bivalents have been examined at late diplotene, diakinesis, and metaphase 1. The X and Y are associated in each by a terminal chiasma between the longer arm of the Y and the arm of the X which is identical as to length with the pairing segment of the Y. The Y-chromosome has a submedian centromere and an arm ratio of approximately 1:1.3. The larger X-chromosome consists of a pairing segment which is of the same diameter as the Y-chromosome and a longer arm which is differentially contracted. The gyres of the differentially contracted portion are approximately one-half the diameter of those in the pairing segment. The more slender arm presents an appearance similar to that of the differential segment of the X-chromosome of the hamsters that are known. The arm of the X-chromosome that is associated with the Y comprises 26 percent of the entire chromosome at meiosis I and the differentially contracted arm 74 percent.

Contrary to the observations of Makino the X-chromosome shows a pronounced differential contraction and is associated with the longer arm of the Y. From Makino's figure it appears likely that he has wrongly interpreted the differential segment to be the Y-chromosome and a portion of

LEGEND TO FIGURE 1.—Ten XY-bivalents from the male chinchilla in late diplotene or diakinesis showing the Y-associated with the X-chromosome by a terminal chiasma. One arm of the X is differentially contracted. 2366x.

the pairing segment of the X. The differential segment appears to be the same diameter as that portion of the bivalent which is described here as the pairing segment of the X and the Y-chromosome.

The X-chromosome as seen in spermatogonial division is the largest chromosome of the complement and is not differentially contracted. This is likewise the situation in the Golden Hamster, *Mesocricetus auratus* as represented by Koller. The Chinchilla should be excellent material for the study of X-bivalent behavior during meiosis in the female since the X-bivalent can be easily distinguished from the autosomes.

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News and Notes

(EDITOR'S NOTE: *News contributions should be sent to the person whose name appears at the end of the appropriate section.*)

JUSTUS HENRY CLINE

October 14, 1875 - July 26, 1954

The Nation, the State, and the Virginia Academy of Science lost a noble scientist and teacher on July 26, 1954, with the death of Justus Henry Cline at the age of 78.

Loved and respected by all, his wise counsel was sought by young and old alike. He was acclaimed throughout the nation for decades because of his foresight, inspiration, energy, and unselfish interest in science in general and conservation in particular.

His monument is in the Uinta Basin, the Big Levels Game Refuge, The James River Monograph, and the dam for the South River Water Supply System.

MARCELLUS H. STOW

A LETTER FROM THE PRESIDENT

Your President takes this opportunity to make two announcements of general interest to the Academy. The first is that the Virginia Journal of Science has now reached its fifth birthday and after a series of growing pains is rapidly approaching maturity. During this period of growth the two men most responsible for the Journal have been Boyd Harshbarger and Horton Hobbs. It is with sincere pleasure that the Council of the Academy announces that both Messrs. Hobbs and Harshbarger have agreed to continue to guide the destinies of the Journal for another period of five years.

Those attending the 1954 meeting of the Academy at Charlottesville will recall the gracious invitation of Dr. Tyler Miller, President of Madison College, to hold our 1955 meeting at that institution. This invitation has been accepted and the dates will be May 12, 13, and 14. Following is a list of the membership of the local committee on arrangements for 1955. It is suggested that specific information may be obtained from the proper person in this group.

LOCAL COMMITTEE ON ARRANGEMENTS

Madison College, May 1955

J. E. Ikenberry—*General Chairman*
B. W. Partlow—*Housing*
W. L. Mengebier—*Registration*
Murl Shawver—*Traffic and Parking*
J. C. Wells—*Junior Academy Exhibits*
E. D. Miller—*Commercial Exhibits*
Wilbert Chappell—*Meeting Rooms and Equipment*
Raus Hanson—*Geology Field Trip*
A. M. Showalter—*Biology Field Trip*
S. C. Bocskey—*Signs and Maps*
R. D. Cool—*Chemical Industry Tour*
C. P. Shorts—*Information*

May I hope that a large number of you will be able to attend this meeting and become acquainted with yet another of the fine colleges of our state.

I. G. FOSTER, *President*

PROPOSED CHANGES IN THE BY-LAWS

Section 5. The Virginia Journal of Science:

ARTICLE 5. The staff shall be composed of an Editor, an Associate Editor, Managing Editor, and an Advertising Manager —— all elected by the Council — . . . .

ARTICLE 5. The Editor shall receive all materials for the Journal, shall send scientific articles to the appropriate Sectional Editors for refereeing, shall act as a referee himself, and shall edit all material published in the Journal.

The Associate Editor shall aid the Editor in preparing materials for the Journal and in correcting proofs.

The Managing Editor shall keep mailing lists that are up-to-date, shall mail all Journals (including Proceedings), shall keep financial accounts on the Journal, shall pay all bills and care for all business, including an annual audit of Books of the Journal —— subject to the regulations and approval of the Academy Council.

The Advertising Manager shall be responsible for securing the proper amount and type of advertising material for the Journal, and shall be responsible to the Managing Editor.

The Sectional Editors shall aid the Editor and Associate Editor in refereeing, and in securing additional referees for scientific articles within their respective fields; in preparing proper announcements and news items for the Journal; and in such other ways as may be advantageous.

SECTION NEWS

AGRICULTURAL SCIENCE SECTION

The Animal Science Conference organized for the purpose of acquainting the faculty of the School of Agriculture with research conducted in this field is again meeting weekly on campus: Staff members of the Departments of Animal Husbandry, Biology, Biochemistry and Nutrition, Dairy Husbandry and Poultry Husbandry participate in the presentations.

Dr. K. A. Huston, dairy cattle breeding extension specialist in the Department of Dairy Husbandry, has resigned to accept a position in research and teaching at Kansas State College. The effective date of his resignation is November 1, 1954.

The newly organized Milk Producers Federation has as its executive secretary Professor R. G. Connelly of the Department of Dairy Husbandry Professor Connelly is on a six months' leave of absence from his duties as extension dairyman to assume this position.

The Southern Regional Collegiate Dairy Products Judging Contest was held on the Virginia Polytechnic Institute campus on October 22, 1954. The Department of Dairy Husbandry acted as host. Ten teams from various southern colleges participated in the contest.

A new pipeline milker and bulk milk holding tank were installed in the new dairy barn in July. The Department of Dairy Husbandry is now in the process of investigating the cleaning and sanitizing of milk pipe lines and conducting time-motion studies on pipe line milkers.

Mr. Earl T. Swink has been appointed Professor and Head of the Department of Agricultural Engineering at Virginia Polytechnic Institute effective July 1, 1954. Mr. Swink has been employed by the Extension Service since April 1, 1935. He received his B.S. and his M.S. degrees here at the Virginia Polytechnic Institute. At the time he was appointed as head of the department he was serving as Extension specialist in rural electrification.

Dr. Wilson B. Bell has been appointed as Associate Director of the Virginia Agricultural Experiment Station. Dr. Bell will continue to conduct research in animal diseases.

Dr. John Pendleton of the Agronomy Department at the Virginia Polytechnic Institute has published a challenging paper entitled "Background For Agronomy." This paper discusses some of the problems facing educators. The paper appeared in Agronomy Journal, September, 1954.

Dr. H. A. Rollins, Jr. has been appointed Associate Professor of Horticulture at Virginia Polytechnic Institute. Dr. Rollins is a native of Connecticut and received his Doctor's degree from Ohio State University at the end of the summer quarter 1954. He will be located at the Winchester Fruit Research Laboratory where he will conduct research and serve as Extension fruit specialist.

Dr. Anthony Lopez has been appointed Professor of Fruit and Vegetable Processing at Virginia Polytechnic Institute. Dr. Lopez came to Virginia from the University of Georgia. He received his Doctor's degree in Food Technology from the University of Massachusetts.

Mr. Arthur L. Eiser, Jr. has been appointed Research Instructor of Horticulture at Virginia Polytechnic Institute. Mr. Eiser will assist with the operation of the Arboretum at the Horticultural Farm. He is a native of Illinois and received his Master's degree from Iowa State College.

The Animal Nutrition research group at Virginia Polytechnic Institute has developed a method of predicting the toxicity of the highly chlorinated naphthalenes by feeding them in special diets to laboratory rats. In this work it was established that a diet rich in protein protects the animals to some extent against poisoning by these compounds. This work is summarized in a paper that will be published shortly in *The Journal of Nutrition*.

The Bacteriology research group at Virginia Polytechnic Institute is working on the manner in which bacteria decompose cellulose. This process is vital to high roughage feed utilization by livestock, soil humus formation, and waste disposal in the pulp and paper industry. Apparently, the breakdown occurs simultaneously anywhere along the plant fibre, rather than by cutting off small fragments from one end. A new product of cellulose breakdown, which is thus far only of theoretical importance, has been discovered.

Dr. W. A. Hardison of the Department of Dairy Husbandry is presenting the results of a cooperative study with the Department of Biochemistry and Nutrition and the Department of Statistics at the annual meeting of the American Society for Animal Production in Chicago on November 26, 1954. Results of an extensive experiment designed to establish the reliability of short-cut methods for determining the digestibility of feedstuffs by cattle will be presented.

Dr. W. E. C. Moore has recently joined the Department of Biochemistry and Nutrition at Virginia Polytechnic Institute. Dr. Moore will be two-thirds time on teaching staff in Bacteriology and will devote one-third time to Virginia Agricultural Experiment Station research on rumen microorganisms.

Dr. James H. Bywaters and Dr. Clayton E. Holmes of the Virginia Polytechnic Institute Poultry Department attended the annual meeting of the Technical Committee of the Southern Regional Poultry Breeding Project at the University of Georgia on the 4th and 5th of October. Dr. Bywaters is the Virginia representative on the Committee. During the meeting the new Southern Regional Poultry Testing Station was inspected by the twelve man Committee and their associates. This testing station is a cooperative project between the 13 southern states and the Research Service of the United States Department of Agriculture and is designed to test, under common conditions, the several strains of chickens independently developed at each station. The Virginia Agricultural Experiment Station will have 3 or 4 strains on test in the 1955 season.

Calvin C. Craighead was appointed to the position of Plant Superintendent and Instructor in Poultry Husbandry in July. He completed the requirements for a B.S. degree in Poultry Husbandry during the first term of summer school 1954.

Denver D. Bragg was moderator of a panel which discussed "The Extension Poultry Specialist's Responsibility to Improve 4-H Poultry Club Work" at the annual meeting of the Poultry Science Association which was held at Purdue University in July. Lee W. Herrick and Dr. James H. Bywaters also attended this meeting.

R. S. Westing, Jr., Extension Swine Specialist at the Virginia Polytechnic Institute, resigned from the Animal Husbandry Department effective November 1 to work with the Augusta County, Virginia Farm Bureau as Agricultural Field Man. Dr. T. J. Marlowe has been appointed Associate Professor in Animal Husbandry Research at the Virginia Polytechnic Institute. He will do Record of Performance work with beef cattle. He received his Ph.D. degree from Oklahoma Agricultural and Mechanical College.

Dr. Martin J. Burrus, formerly on the Animal Husbandry Staff, Oklahoma State, has been appointed Associate Professor in Animal Husbandry Research at Virginia Polytechnic Institute. He will be located at the Front Royal Station where he will be doing animal breeding work.

Mr. Jack Taylor has been transferred to Virginia Polytechnic Institute from Front Royal to take the place of Frank McClaugherty, Instructor in Animal Husbandry, who was promoted to Director of the Field Station at Emory, Virginia.

R. C. Carter, Animal Geneticist in Animal Husbandry, has been recently appointed on the newly formed technical committee which coordinates sheep research in the south. He will be Virginia representative on this regional planning.

David Meyerhoeffer has been appointed Resaerch Instructor of Animal Husbandry at Virginia Polytechnic Institute. Mr. Meyerhoeffer will be located at Front Royal. He received a B.S. degree in General Agriculture at Virginia Polytechnic Institute in June 1954.

Mr. John Henry Carter has been appointed Research Instructor of Animal Husbandry at the Tidewater Research Station. Mr. Carter received his B.S. degree from Virginia Polytechnic Institute in June 1954.

Dr. C. M. Kincaid will give a paper on performance testing work at the November meeting of the American Society of Animal Production in Chicago. Dr. Tom J. Marlowe will present a paper on research in Dwarfism at the same meeting.

A paper entitled "Correlation of Rapid Soil Tests with Chemical Composition and Yield of Hay and Pasture Crops in Virginia" by R. K. Stivers, C. I. Rich, and R. E. Blaser of the Agronomy Department, Virginia Polytechnic Institute, was presented at the annual meeting of the American Society of Agronomy and Soil Science Society of America at St. Paul, Minnesota, November 8-12, 1954.

WESLEY P. JUDKINS, *Virginia Polytechnic Institute*

ASTRONOMY, MATHEMATICS, AND PHYSICS SECTION

Professors Edward J. McShane and Gordon T. Whyburn attended the International Mathematics Conference in Amsterdam in August 1954. They

were appointed by the National Science Foundation as representatives of the United States at this meeting.

The Department of Astronomy at the University of Virginia held a NEIGHBORS MEETING on October 22-23 which was attended by some 30 astronomers from the eastern and southeastern sections of the country. Informal discussions were held on various topics in astronomy.

Dr. Heinrich Eichhorn, who received his Ph.D. at the University of Vienna, has joined the staff of the Leander-McCormick Observatory for the 1954-55 session. He holds a National Science Foundation fellowship and will study motions of stellar associations. Miss Marguerite Risley of Randolph Macon Women's College is also working at the Leander-McCormick Observatory with members of the staff for the current session.

Dr. Stephan Berko, who spent the past year at Princeton University as a National Research Foundation Post-doctoral Fellow, has joined the faculty of the Department of Physics at the University of Virginia where he will continue work in nuclear physics.

Dr. John W. Stewart, who received his Ph.D. in June 1954 at Harvard University, has been awarded a post-doctoral fellowship in physics at the University of Virginia. Dr. Stewart will continue his work on the compressibility of solidified gases at liquid helium temperatures.

National Science Foundation Pre-doctoral Fellowship for the current session have been awarded to Messrs. John B. Breazeale and Melvin M. Levine, graduate students in physics at the University of Virginia. New basic research contracts have been awarded the Department of Physics of the University by the National Science Foundation and the Atomic Energy Commission. The National Science Foundation contract is for the sum of, $9,800.00 to support work by Professor J. W. Beams on molecular weight measurements by the ultracentrifuge method. The Atomic Energy Commission contract totalling $37,500.00 will support work by Professor Frank L. Hereford and Stephan Berko on interactions of polarized gamma rays. This program will include installation of a low energy, high current Van de Graaff machine. The Atomic Energy Commission has also awarded two other proposals for research contracts at the University of Virginia. Professors Nicolas Cabrera and Allan T. Gwathmey will receive support for their work on nearly perfect crystals. Also the Ordnance Research Laboratory, which is associated with the Department of Physics, will receive support of work involving new centrifuge techniques.

F. L. HEREFORD, *University of Virginia*

BACTERIOLOGY SECTION

The 199th meeting of the Washington Branch of the Society of American Bacteriologists was held jointly with the Maryland and Virginia Branches on Saturday afternoon and evening, October 23, 1954, at the Army Medical Service Graduate School. The following program was presented. (1) Studies on the Mechanism of T-2 Bacteriophage Infection —— Roger M. Herriott, School of Hygiene and Public Health, Johns Hopkins University. (2) The Sterilization of Culture Media Ingredients with Ethylene

Oxide — Leo F. Judge, Michael J. Pelczar — Department of Bacteriology, University of Maryland, College Park, Maryland. (3) Some Observations on the Nucleic Acids of Entozoic Amebae — Virginia J. Fuller, Angus M. Griffin — Department of Bacteriology, Hygiene and Preventive Medicine, George Washington School of Medicine, Wash., D. C. (4) Effect of Aeration Level on Sporulation of Aerobic Bacilli — Norman B. Roth, David H. Lively, and Howrad M. Hodge — Camp Detrick, Frederick, Maryland. (5) A Paper in Reference to Virology — Thomas C. Ward, School of Hygiene and Public Health, Johns Hopkins University. (6) Xylose Dissimilation by *Propionibacterium pentasaceum* — Wesley A. Volk, University of Virginia School of Medicine, Charlottesville, Virginia. (7) Tissue Culture in Microbiology — Karl Habel, Chief of Basic Studies Section Laboratory of Infection Diseases in the National Microbiological Institute of the National Institute of Health.

J. DOUGLAS REID, *Richmond*

BIOLOGY SECTION

Mr. Heiden T. Cox, having spent a year on leave to serve as Deputy Executive Director of the American Institute of Biological Sciences, has returned to the Virginia Polytechnic Institute.

Mr. Frederick S. Orcutt, who has been on leave of absence to serve as Professor of Bacteriology at the University of Hawaii, has returned to his position at the Virginia Polytechnic Institute.

The Virginia Polytechnic Institute announces the completion of a new research laboratory for animal diseases which has been constructed on the Price's Fork Road near Blacksburg. The research in the new laboratory is directed by Mr. Wilson B. Bell.

Mr. A. A. Muka joined the staff of the entomology section at the Virginia Polytechnic Institute as associate professor. Mr. Muka was recently awarded the doctorate at Cornell University.

Mr. Horton Hobbs, University of Virginia, was elected a member of the American Society of Naturalists at its last meeting in recognition of his excellent contributions to the field of crayfish ecology, distribution and evolution.

Mr. John Bayard Burch received the Master's degree from the University of Richmond in June 1954 and is now working towards the doctorate at the University of Michigan.

Charles M. Lankford, Jr., Commissioner of Fisheries of Virginia, was unanimously elected Chairman of the Atlantic States Marine Fisheries Commission for the coming year at their meeting held at Baltimore. The Commission has a membership of fifteen Atlantic Coast states and meets annually to coordinate the fisheries research programs and to discuss legislation and other matters concerning the fisheries. The Commission was organized in 1942.

The College of William and Mary was recently host to the Atlantic Estuarine Research Society. Members of the Society, brought together by a common interest in the physics, chemistry, and biology of estuaries

such as Chesapeake and Delaware bays, meet twice yearly to discuss research projects.

The family of the late Professor W. D. Hoyt of Washington and Lee has given the Department of Biology an excellent research microscope in memory of Professor Hoyt.

Mr. John E. Davis, Jr. has returned to the Biology Department of Washington and Lee as instructor in Biology. Mr. Davis attended Mountain Lake Biological Laboratory during the summer of 1954 where he was engaged in research leading toward the doctorate at the University of Virginia.

Mr. Bertram B. Hanna joined the faculty of the Medical College of Virginia in September 1954 as an A. D. Williams fellow in the Department of Biology and Genetics. Mr. Hanna's research interests are population and medical genetics.

The Mountain Lake Biological Station of the University of Virginia celebrated its Silver Anniversary on July 17, 1954. The formal celebration was preceded by a social gathering at the Mountain Lake Hotel and open house at the Station. Professor Bruce D. Reynolds, Director of the Station presided at the formal program. The Invocation was given by the Reverend Ellison Smyth of Blacksburg, Virginia. Ivey F. Lewis, Dean of the College of Arts and Sciences, University of Virginia and formerly Director of the Station (retired), traced the history of the Station from its beginnings in the Thompson Cottage on the hotel grounds to the present modern stone laboratory. The principal address was delivered by Mr. C. E. Sunderlin, Deputy Director of the National Science Foundation, who spoke on the "*Sinews of Science*". This address is the lead article in the present number of this Journal. The Benediction was pronounced by the Reverend Daniel B. Suter of Eastern Mennonite College. The celebration was attended by many distinguished guests and former students of the Mountain Lake Biological Station.

ROBERT T. BRUMFIELD, *Longwood College*

CHEMISTRY SECTION

Dr. Eugene D. Crittenden, Director of Research, Nitrogen Division, Allied Chemical and Dye Corporation, has been named by the Virginia Section of the American Chemical Society as the recipient of its Distinguished Service Award, which is given annually for outstanding contributions to the professional standing of chemists.

Herbert Felix Sanders, Director of Science for the Martinsville School Division, was also selected by the Virginia Section to receive its second Distinguished Service Award, which is given for excellence in science teaching in the secondary schools of Virginia. These awards are made possible each year by a gift from Mrs. Henry K. McConnell of Richmond in memory of her husband, who was a former chairman of the Section and a recognized leader in industrial chemistry in the South.

A number of Virginia chemists presented papers at the September meeting of the American Chemical Society held in New York. Dr. Frank A.

Vingiello, with Alexej Borkovec and Joseph Shulman, Virginia Polytechnic Institute, discussed "The Synthesis of 10-Phenyl-1,2-benzanthracene and the Three Isomeric 10-Monmethyl-1,2-benzanthracenes." Dr. William P. Boyer, Director of Research, Virginia-Carolina Chemical Corporation, served as chairman of a symposium on "Resources for the Chemical Industry in the South Atlantic States" in which three other Virginians participated: Allan T. Gwathmey, University of Virginia, spoke on "Research and Educational Resources of the South Atlantic States"; Edward A. Wayne, First Vice-President of the Federal Reserve Bank of Richmond, presented "Financial Resources of the South Atlantic States"; Edwin Cox, Vice-President of the Virginia-Carolina Chemical Corporation, discussed "Chemical Industry in the South Atlantic States". Mr. Cox was also luncheon speaker for the American Chemical Society Division of Fertilizer and Soil Chemistry. His topic was "Plant Food Research — Evolution or Revolution". Herschel S. Jenkins, also a Virginia-Carolina Chemical Corporation staff member, read a paper on "Proteins as Fiber-Forming Materials", and Henry Leidheiser and Victor J. Kehrer, members of the Virginia Institute for Scientific Research, discussed the "Catalytic Decomposition of Carbon Monoxide on Large Metallic Single Crystals. James E. Worsham, Jr., with H. A. Levy and S. W. Peterson of the Oak Ridge National Laboratory, presented a paper on "Neutron Diffraction Investigation of the Positions of Hydrogen Atoms in Urea Crystals". Dr. Worsham has recently joined the staff at the University of Richmond, transferring from Hampden-Sydney College. Dr. J. Stanton Pierce and A. G. Richardson of the University of Richmond gave a paper on the subject of "Tetrazolium Salts". Representing the University of Virginia, in addition to Dr. Gwathmey, were Dr. Alfred Burger, who with A. Chandler Schmalz presented a paper on "The Action of Hydrochloric and Nitric Acid on Some Derivatives of Phenothiazine", Robert J. Gibbs and Alfred Chanutin, who discussed the "Denaturation of Human Plasma Albumin with Reference to pH and Ionic Strength", and Dr. Robert E. Lutz and W. Bruce Black, whose paper was entitled "Ultraviolet Absorption Spectra of Chalcones — Partial Chromophores". Dr. Burger also gave the Paul Ehrlich Centenary Memorial Lecture before the Division of Medicinal Chemistry. His talk was reprinted in the October 18 issue of *Chemical and Engineering News*.

Additional publications which have been reported are the following: From Randolph-Macon Woman's College, Julia T. Gary and Lucy W. Pickett, "The Far Ultraviolet Absorption Spectra of the Isomeric Butenes" in *J. Chem. Phys.*, 22, 599 (1954); also by the same authors a similar paper on isomeric hexenes, *ibid.*, p. 1226. From Virginia Polytechnic Institute, Philip C. Scherer and Norbert J. Crookston, "Solvation of Cellulose Nitrate in Acetone-Water", *J. Polymer Sci.*, 14, 129 (1954); John W. Murray, "The Decomposition of Calcite and Aragonite in Caves", *J. Geol.*, 62 (1954); Robert C. Krug and P. J. C. Tang, "The Preparation of Diakyl zinc Compounds". *J. Am. Chem. Soc.*, 76, 2262 (1954). From the Medical College of Virginia, C. C. Clayton and J. D. Spain, "Reticulo-Endothelial System and Azo Dye Carcinogenesis", *Fed. Proc.*, 13, 193 (1954); J. C. Forbes, J. A. Board, and G. M. Duncan, "Adrenal Response of Rats

to Salicylamide and Sodium Salicylate With and Without Para-Aminobenzoic Acid", *Proc. Soc. Exp. Biol. and Med.*, 85, 37 (1954); J. C. Forbes, P. D. Camp, W. R. Jordan, O. M. Petterson, and C. Korn, "Serum Cholesterol Fractionation Studies", *Sou. Med. J.*, 47, 226 (1954). Also G. W. James, L. D. Abbott, J. W. Brooks, and E. I. Evans, "The Anemia of Thermal Injury, III—Erythropoiesis and Hemoglobin Metabolism Studied with N^{15}-Glycine in Dog and Man", *J. Clin. Inv.*, 33, 150 (1954); G. W. James and L. D. Abbott, "Erythrocyte Destruction in Sickle Cell Anemia: Simultaneous N^{15}-Hemin and N^{15}-Stercobilin Studies", *Clin. Res. Proc.*, 2, 57, (1954); L. D. Abbott and M. J. Dodson, "Inhibition of *In Vitro* Heme Synthesis From N^{15}-Glycine by 2-Ethyl-5-Methylbenzimidazole", *Proc. Soc. Exp. Biol. and Med.*, 86, 475 (1954).

On the academic front a number of staff changes have occurred. At Hampden-Sydney College Dr. James M. Frederickson, formerly at Davis-Elkins College, has replaced Dr. T. H. Pearson as Head of the Chemistry Department. Dr. Pearson is now associated with the Ethyl Corporation in Louisiana. Charles W. Bondurant has also rejoined the Hampden-Sydney staff after a year of graduate study at Virginia Polytechnic Institute. A newcomer to the Biochemistry Department of the Medical College of Virginia is Dr. Richard L. Hardin. Dr. Hardin received his Doctor's degree from the University of Wisconsin and taught formerly at the University of Louisville Medical School. From Randolph-Macon Women's College: Miss Helen V. Pashko, Instructor in Chemistry, has resigned to accept a position with Olin Industries in New Haven, Connecticut. Dr. Laura Bliss, Assistant Professor of Chemistry, has been granted a leave of absence and will study at Cambridge University in England this year. Her teaching duties will be taken over by Miss Julia T. Gary, who has joined the staff as an Instructor in Chemistry. Miss Gary is an alumna of Randolph-Macon and received her Master's degree from Mount Holyoke. She taught at Mount Holyoke last ear and was engaged in research there. Miss Gloria Sober, A.B. from the University of Pittsburgh, was also appointed as Instructor in Chemistry. Miss Sober has completed her work for her Master's degree at Pittsburgh and will receive the degree in February. Dr. Nan V. Thornton, Chairman of the Chemistry Department, has returned from a leave of absence which she spent doing research at the University of Chicago.

From Roanoke College Dr. Ashley Robey reports that Mrs. Leroy (Norma B.) Moran has been added to the staff as an Instructor in Chemistry. Mrs. Moran received her B.S. degree from Lynchburg College and her M.S. degree from the University of Tennessee. Dr. Thomas C. Franklin, formerly at the University of Richmond, is now an Assistant Professor of Chemistry at Baylor University. His replacement, as noted previously, is Dr. James E. Worsham, Jr. Dr. Worsham holds a B.S. from Richmond, a M.S. from Vanderbilt University, and a Ph.D. from Duke University. A recent addition to the staff at the University of Virginia is Dr. Loren G. Hepler, who will serve as an Assistant Professor. Dr. Hepler received his Ph.D. in Physical Chemistry from the University of California and has been working as a postdoctoral fellow at the University of Minnesota. Dr.

Nicholas Cabrera has been made Professor of Chemistry and Physics at Virginia. He was formerly an Associate Professor of Physics, but will now offer a course in quantum mechanics for chemists in alternate years. Dr. Ralph E. Thiers, Assistant Professor on leave of absence, is continuing his work in the Biophysics Research Laboratory at the Peter Bent Brigham Hospital in Boston.

At Virginia Polytechnic Institute Dr. Russell E. Leed, who has been on official leave with the Atomic Energy Commission, has resigned his position as Associate Professor to accept a permanent appointment with the Atomic Energy Commission at Oak Ridge, Tenn. Edward C. Kramer, Instructor in Chemistry, has transferred to Clemson College. Dr. Ralph G. Steinhardt has joined the staff as an Associate Professor of Chemistry. He was formerly an Assistant Professor at Lehigh University, from which he received his B.S., M.S., and Ph.D. degrees. He also holds a B.S. degree in Chemical Engineering from Virginia Polytechnic Institute. Dr. Luther K. Brice has also been added to the Chemistry staff as an Assistant Professor. Dr. Brice has a B.A. degree from Harvard University, a M.A. from Dartmouth College, and has just completed requirements for his Ph.D. at Duke University. His specialty is physical chemistry.

Among the changes in personnel taking place on the industrial scene the following have been reported by the Virginia-Carolina Chemical Corporation, Richmond. Dr. J. Samuel Gillespie, Jr., former Group Leader with the Fiber Research Unit, has been transferred to the Fiber Division in New York. Charles L. Harowitz has been promoted to Group Leader of Organic Research in Richmond. Paul H. Coffey and Taylor G. King, both of the University of Richmond, have been added to the research staff, the former with the Organic Research Group and the latter with the Fiber Unit. John M. Daniel, who received his bachelor's degree from the University of Virginia and his master's degree from the Georgia Institute of Technology, has joined the chemical engineering staff, and Leslie H. Jenkins has been appointed Senior Chemist with the Inorganic Division. Jenkins received both his bachelor's and doctorate from the University of North Carolina. Dr. John P. Horton has been added to the Development Department. He is a graduate of the Massachusetts Institute of Technology and was formerly associated with the National Dairies Research Laboratories.

Concurrently with a physical expansion in their research facilities a number of additions to the research staff have been announced by the American Tobacco Company in Richmond. These include Miss Barbara Anne Eanes. B.S. Mary Washington College, as Analytical Chemist; Mrs. Darien Dorn Mahaffee, B.A. Lander College and M.S. University of South Carolina; and J. Scott Osborne, M.S. Wake Forest College, both as Research Chemists; as Research Biochemist, Burton M. Pogell, B.A. Johns Hopkins University and Ph.D. University of Wisconsin. Also added to the staff as Research Biochemist is Dr. William A. Peabody. Dr. Peabody holds a degree in Chemical Engineering from the Colorado School of Mines and a M.S. and Ph.D. from the University of Colorado. He

was formerly associated with the Valentine Meat Juice Company in Richmond.

An addition to the building of the American Tobacco Company Research Laboratory is now being constructed and is expected to be completed by the end of January 1955. The new addition will double approximately the present laboratory space, and on completion will be used to house the research departments. Control work will be coordinated entirely within the present building. The new quarters have been carefully planned to provide the most modern facilities and equipment needed for the Laboratory's work. Research on tobacco and tobacco smoke will be facilitated by the latest analytical methods, including mass spectrometry and emission spectrography. Equipment for radiological studies will also be available. The Company is also financing through a grant of 120,000 dollars the construction of a greenhouse at the Medical College of Virginia, which will be used for growing radioactive tobacco. The structure will consist of an ordinary greenhouse with a smaller sealed chamber for growing radioactive plants. Tobacco uniformly labelled with C^{14} will be obtained by growing the tobacco plants in an atmosphere containing the radioactive isotope Carbon 14 as carbon dioxide. The whole plant or individual compounds will then be used in the biological research program sponsored by the American Tobacco Company at the Medical College of Virginia and also in the chemical and physical studies of tobacco and tobacco smoke conducted in its own laboratory. The greenhouse will be one of the few in this country with facilities for growing radioactive plants.

Some other items of interest. Herschel S. Jenkins, Section Leader of Virginia-Carolina's Fiber Research Section participated in the Fourth Canadian Textile Seminar at Queen's University, Kingston, Ontario in September. His paper, "Textile Fibers From Proteins", has been published in "The Book of Papers of the Fourth Canadian Textile Seminar of the Textile Technical Federation of Canada".

The Virginia-Carolina Chemical Corporation is continuing its fellowships at the University of Virginia for research on organic-phosphorus compounds under the direction of Dr. Alfred Burger. The Company also sponsors fellowships for graduate study on pesticides at Cornell, Rutgers, and Louisiana State University.

The Army Ordnance Works is sponsoring two projects at Virginia Polytechnic Institute under the direction of Dr. Philip C. Scherer and one under the supervision of Dr. Frank A. Vingiello. The Air Force Commission is sponsoring a project under Dr. Robert C. Krug. Dr. F. B. Clough, Assitant Professor of Chemistry at Virginia Polytechnic Institute served as a Research Participant at Oak Ridge during the summer.

Miss Imogene Claiborne, Assistant in Chemistry at Randolph-Macon Women's College, received a Grant-In-Aid from Duke University for study during the summer months.

Dr. James E. Worsham, University of Richmond, has been awarded a grant from the Research Corporation for the study of dipole moments of organic compounds, and Miss Velta Erdmanis, a graduate of the Uni-

versity of Richmond, has been awarded a research assistantship made available by the same agency. Mr. James W. Cook has been awarded a Pur-year fellowship for graduate study in chemistry.

From the University of Virginia: A copy of a Technical Report entitled "Survey of the Literature on Antioxdants and Anticorrosion Additives for Lubricants at Elevated Temperatures" by Drs. A. F. Benton, Alfred Burger, and J. W. Cole has been presented to the Chemistry Library. This report results from an Air Force Project which is entering its fourth year. Dr. J. W. Cole is the Principal Investigator. Dr. Cole is also serving as Consultant on the Advisory Panel for the Division of Scientific Personnel and Education of the National Science Foundation. Last year he was a member of the Fellowship Screening Panel of the National Research Council. Dr. Allan T. Gwathmey of the University faculty was invited to present a paper in Paris to the Societé de Chimie Physique but was not able to make the trip. In his absence a paper by Drs. Gwathmey and R. E. Cunningham was read before the Society for the authors by Mme. Adrienne Weill. Madam Weill, who was a pupil of Marie Curie, spent several days at the University last year and gave two lectures on Marie Curie and on the discovery of radium to the General Chemistry Class.

Dr. John H. Yoe, Chairman of the Chemistry Department of the University of Virginia, Dr. A. T. Gwathmey, and Dr. Bruce Wagner attended the Gordon Conference last August. Dr. Wagner will attend the Massachusetts Institute of Technology next year as a postdoctoral fellow, working with Dr. Carl Wagner. As a guest of the General Electric Company Dr. Yoe also visited prior to the American Chemical Society Meeting in New York the research laboratories and industrial plants of the General Electric Company in the Schenectady area. At the American Chemical Society Meeting he was elected to the Council Policy Committee for a term of three years, beginning the first of January. Dr. Robert E. Lutz and Dr. James W. Cole will present papers at the American Chemical Society Southeastern Regional Meeting which meets in Birmingham in October.

Dr. E. S. Gilreath, Associate Professor of Chemistry at Washington and Lee University is the author of a text entitled "Qualitative Analysis Using Semimicro Methods" published in September by McGraw-Hill. Dr. John H. Wise, also of the Washington and Lee staff held an appointment at Oak Ridge during the summer. He was engaged in work on high-resolution spectroscopy.

A conference on "Undergraduate Research in Chemistry", sponsored by the National Science Foundation, was held at Washington and Lee last May. Dr. L. J. Desha, Head of the Chemistry Department, served as Chairman of the Planning Committee and as the Washington and Lee Representative. Thirty-two colleges and universities selected from all parts of the country participated in the conference. The College of William and Mary, with Dr. William G. Guy, Head of the Chemistry Department, as its representative, was the only other Virginia school represented at the Conference. Teachers who are interested in the problems of undergrad-

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uate research will certainly find the Report of the Conference to be stimulating and worthwhile reading.

CARL J. LIKES, *Virginia Institute for Scientific Research*

ENGINEERING SECTION

After 19 years as head of the Chemical Engineering Department at Virginia Polytechnic Institute, Dr. Frank C. Vilbrandt has relinquished this administrative position to Dr. Fred W. Bull who has been on the faculty there since 1938. Dr. Vilbrandt will continue to serve as Professor of Chemical Engineering.

Dr. Fred Bull attended the seminar on teaching methods held by the General Electric Company in Schenectady, New York from August 30 to September 4.

Dr. Dale S. Davis of the Chemical Engineering Department of Virginia Polytechnic Institute is the contributor of a section entitled "Nomography" in the Chemical Business Handbook recently published by McGraw-Hill.

Dr. Nelson F. Murphy of the Chemical Engineering Department at Virginia Polytechnic Institute addressed the New York Section of the American Electroplaters' Society in Syracuse, New York on September 17.

In August, Dean John W. Whittemore of Virginia Polytechnic Institute and Drs. Fred Bull. and P. H. Watkins from the Chemical Engineering Department attended the meeting of the south central group of the National Council for Stream Improvement held in Lynchburg.

Dean Whittemore also attended a meeting held in Minneapolis, Minnesota of the National Council of State Boards for Engineering Examiners as representative of the National Institute of Ceramic Engineers.

Dr. Lawrence R. Quarles, Assistant Dean of the School of Engineering of the University of Virginia, has been relieved temporarily of part of his teaching duties in order to serve as consultant to the Oak Ridge National Laboratory on problems involving control of the homogeneous reactor.

Dr. Otis L. Updike, Jr., of the Chemical Engineering Department of the University of Virginia is on leave of absence for the session of 1954-1955 and is employed by the Naval Air Missile Testing Center at Point Mugu, California. He is obtaining valuable experience in the design and construction of electrical computers and their use in solving engineering problems.

Dr. Robert M. Hubbard of the Chemical Engineering Department of the University of Virginia attended the American Institute of Chemical Engineers First International Nuclear Energy Congress in Ann Arbor, Michigan in June.

Mr. Tilton E. Shelburne and Mr. Phillip Melville of the Virginia Council for Highway Investigation and Research at the University of Virginia, and Mr. Alfred Manor of the Virginia Department of Highways attended the Annual Highway Conference at the Virginia Military Institute in October. Mr. Melville presented a paper on "Quality Concrete." Mr. Phillip

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Melville spent the months of June and July in Europe and visited England, France, and Italy during that time.

ROBERT M. HUBBARD, *University of Virginia*

GEOLOGY SECTION

Of much interest to all members of the Geology Section was the publication in October, 1954 of the first issue of *Virginia Minerals*, the new quarterly of the Virginia Division of Geology. Upon request, the Division of Geology will be happy to put your name on its mailing list to receive future copies of *Virginia Minerals*. The new publication is designed to acquaint the public with the mineral resources of Virginia and to provide geologic information leading to their exploration.

"Geology and Oil Possibilities of the Rose Hill District, Lee County, Virginia" by Ralph L. Miller and J. Osborn Fuller is slated to appear soon as Bulletin 71 of the Virginia Division of Geology.

The Geology Department of Washington and Lee University is forming a collection of specimens of minerals and rocks representing radioactive deposits throughout the United States. Radioactive specimens collected to date represent about 35 eastern and 20 western localities. Radiometric instruments in the Department consist of a Precision Model III Scintillator, an El-Tronics Model SM-3 Geiger counter, a Mineral Engineering Co. Model 600-A Geiger counter for making radiometric assays, a Tracerlab Model SU-7 Geiger counter, and long-wave and short-wave ultraviolet Mineralights.

Titanium-bearing ores in the Vinton-Stewartsville area of Virginia were investigated during August 1954, by C. E. Sears of the Virginia Polytechnic Institute Geology Department. The Bush-Hutchins lead near Vinton was extended about a quarter of a mile to the southwest. An investigation was also made of a 20-foot outcrop of what appears to be a high-grade titaniferous ore on the Mcleod farm southeast of Stewartsville. Further investigation of these deposits using magnetic equipment to supplement surface geology is planned in the near future.

Dr. Jean Lowry, geologist of the Virginia Division of Geology, spoke on *Caves of Virginia* at a meeting of the Holden Society of Virginia Polytechnic Institute on September 21, 1954. Her talk was illustrated by numerous kodachrome slides showing many interesting cave formations.

"The Deposition of Calcite and Aragonite in Caves" by Dr. John W. Murray, professor of Chemistry, Virginia Polytechnic Institute appeared in the September 1954 issue of *The Journal of Geology*.

During the past summer Wayne E. Moore of the Virginia Polytechnic Institute Geology Department began a study of the sands associated with the coastal terraces of Virginia. The relationship of coastal geomorphology to the properties of the sands is being investigated.

The sedimentation tank at the Virginia Polytechnic Institute has been fitted with a wave-maker that can generate waves of three different amplitudes at each of three different frequencies. The tank and wave apparatus are being used to study sedimentation processes of rivers and coasts.

W. D. LOWRY, *Virginia Polytechnic Institute*

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PSYCHOLOGY SECTION

A large number of Virginia psychologists attended the annual meetings of the American Psychological Association in New York, September 1-8. William M. Hinton and Stanley B. Williams were delegates from Virginia at the workshop on legislation sponsored by the Conference of State Psychological Associations. Mr. Hinton also represented Virginia at the two meetings of the State Board of Examiners. Frank W. Finger was chairman of a symposium, New Courses in Introductory Psychology, sponsored by the Division on the Teaching of Psychology. L. Starling Reid chaired a symposium, The Place of the Concept of Drive in Motivation Theory, sponsored by the Division of General Psychology. Richard H. Henneman presented a paper on the program of the Division of Military Psychologists. Frank A. Geldard is president-elect of the Division of Experimental Psychology. Frank W. Finger is chairman of the Committee on Undergraduate Education of the Education and Training Board of the American Psychological Association.

During the New York meetings of the American Psychological Association, there was held an organization meeting of a new regional psychological association representing the states below the Mason-Dixon Line and east of the Mississippi River. The new association will be known as the Southeastern Psychological Association. Virginia psychologists have been invited to affiliate with this association.

Officers of the Richmond Psychological Association for 1954-55 are: Dr. Cyril Mill, Richmond Public Schools, president; Dr. Robert Filer, University of Richmond, vice-president; and Dr. Jacob Silverberg, McGuire Veterans Hospital, secretary-treasurer.

Several personnel changes have occurred in the Psychology Department at the University of Virginia. Frank W. Finger has returned after a year's leave of absence at Yale on a Ford Foundation Fellowship. Kenneth E. Lloyd, a recent Ph.D. from Ohio State University, has been appointed assistant professor of psychology. Raymond E. Bice has been appointed director of admissions at the University. Evan G. Pattishall has been appointed assistant professor of educational research in the School of Education. Richard H. Henneman was promoted from associate professor to professor of psychology, and L. Starling Reid, from assistant professor to associate professor of psychology.

Miss Marjorie Brownell is on leave of absence from Randolph-Macon Woman's College to do advanced graduate work at the University of Massachusetts. Mr. Paul Mountjoy, of the University of Indiana, is filling her place in the department.

RICHARD H. HENNEMAN, *University of Virginia*

SCIENCE TEACHERS SECTION

A conference on Biology Teaching, sponsored by the National Association of Biology Teachers in cooperation with the American Institute of

Biological Sciences and made possible by a grant from the National Science Foundation, was held in Gainesville, Florida, during the latter part of August and early September.

Approximately 100 persons — including research biologists, high school and college teachers of biology, and professional educators — from 17 states, the District of Columbia, and the Canal Zone were invited and participated in the discussions. Representatives were also present from the American Association for the Advancement of Science, the National Research Council, and the National Science Foundation.

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The Conference was under the direction of Dr. Richard Weaver of the University of Michigan, and Mr. George Jeffers of Longwood College, Mr. Samuel L. Meyer of Florida State University, Mr. Ned Bingham of the University of Florida, and Mr. Hugh Stickler of Florida State University served as staff members.

Delegates from Virginia were Miss Samuella Crim of Broadway High School, Miss Susie V. Floyd of Newport News High School, Mr. Horton H. Hobbs of the University of Virginia, Mr. Jeffers, Mr. Charles E. Packard of Randolph-Macon, Ashland, Mr. J. V. Parnell of Virginia State College, and Mr. Percy H. Warren of Madison College.

CAROLINE GAMBRILL, *Waynesboro*

STATISTICS SECTION

Dr. D. B. Duncan has resigned his position as professor of statistics at the Virginia Polytechnic Institute effective December 31, 1954, and has accepted a position as professor and statistical consultant at the University of Florida in Gainesville.

Dr. R. A. Bradley has been granted a leave of absence from the Virginia Polytechnic Institute from February 1 to May 31. During this period, he will be a visiting professor in the Department of Mathematics and Applied Statistics at Rutgers University.

Dr. John E. Freund, who has been a visiting professor at the Virginia Polytechnic Institute since September of 1954 and on leave of absence from Alfred University, has resigned his position at Alfred in order to accept a permanent position at the Virginia Polytechnic Institute.

The following members of the Statistics Department of the Virginia Polytechnic Institute attended and presented papers at the joint session at Montreal, Canada, Septmeber 10-13: Dr. Boyd Harshbarger, "2^3 Factorial in a Latinized Rectangular Lattice Design"; Dr. George L. Edgett, "Multiple Regression with Missing Observations Among the Independent Variables"; Dr. Ralph A. Bradley, "A Note on the T-Distribution for Samples from a Bi-Modal Population and a Skew Population"; Dr. William A. Thompson, "A Topic in Variance Components Analysis"; Dr. Paul N. Somerville, "Optimum Sampling in Multinomial Populations"; Dr. David B. Duncan, "Simultaneous Confidence Intervals Derived from Multiple Range and Multiple F. Tests"; Mr. Hale S. Sweeny, "Analysis of Experiments with Correlated Observations and Heterogeneous Variances"; Dr. John E. Freund, and Mr. Thomas S. Russell.

Dr. William A. Thompson, associate professor of statistics at the Virginia Polytechnic Institute and principal investigator of a contract sponsored by the Quartermaster Corps of the United States Army, received a Doctor of Philosophy degree in Statistics from the University of North Carolina in August 1954.

Dr. William E. Cook has resigned his position at the Richmond Professional Institute and has accepted a position with Alton State Hospital, Alton, Illinois.

The following are recent publications of members of the Department of Statistics of the Virginia Polytechnic Institute: "Statistical Methods Applied to Highway Research Experimentation", by D. B. Duncan, *Proc. Highway Research Board*, 33, 1954; "Multiple Range and Multiple F Tests", by D. B. Duncan, *Biometrics*, II, 1955; "Rank Analysis of Incomplete Block Designs, Additional Tables for the Method of Paired Comparisons," by R. A. Bradley, *Biometrika*, 41, 319, December 1954; "Incomplete Block Rank Analysis: On the Appropriateness of the Model for a Method of Paired Comparisons", by R. A. Bradley, *Biometrics*, 10, 375, September 1954; "A 2 x 2 Factorial with Paired Comparisons", by R. A. Bradley and R. M. Abelson, *Biometrics*, 10, December 1954; "Some Problems of Optimum Sampling", by P. N. Somerville, *Biometrika*, December 1954, Parts 3 and 4, Vol. 41.

LIONEL WEISS, *University of Virginia*